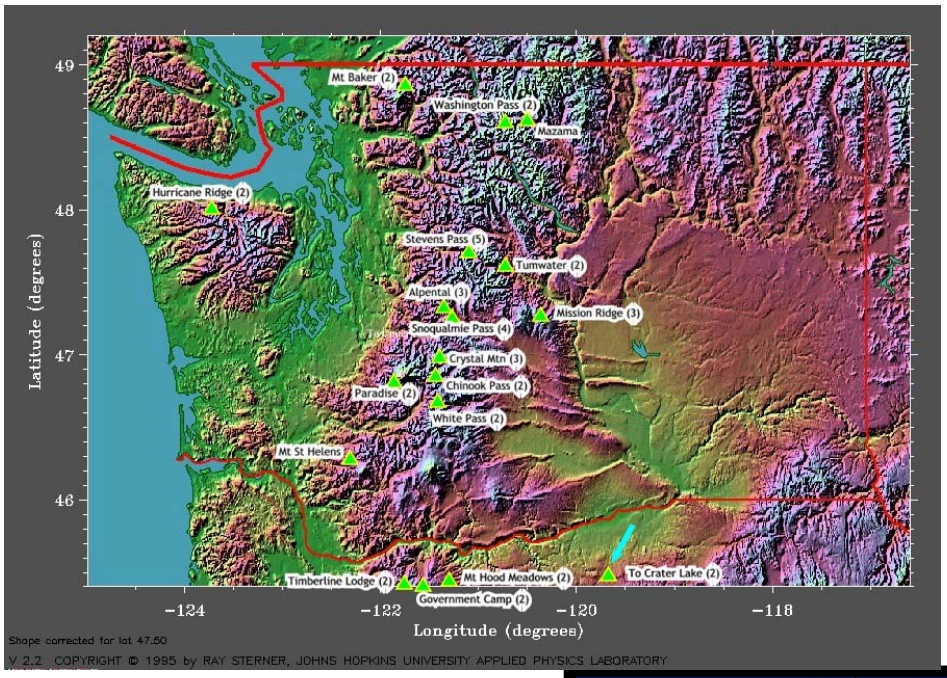


Northwest Weather and Avalanche Center

2002-2003 Annual Report— May 2003

Report Prepared by Mark Moore, Garth Ferber and Kenny Kramer

A partnership between the USDA Forest Service, Washington State Department of Transportation, Washington State Parks and Recreation Commission, Washington State Snowpark and Snowmobile Programs, National Weather Service, National Park Service, Pacific Northwest Ski Area Association, British Columbia Ministry of Highways, USDA-FS Fee-demo Program, County Title II RAC Program, Friends of the Avalanche Center and others.

United States Department of Agriculture

Forest Service Pacific Northwest Region

Cover Photo credits:

Upper Picture—this raised and shaded relief image of Washington and northern Oregon shows the general distribution of the NWAC's remote weather data network (Crater Lake site is out of the photo at the bottom). Along with strong support from several cooperators (WSDOT, ski areas and NPS), the intensive data network is maintained and managed by NWAC forecast staff, with the goal to provide reliable, hourly, real-time mountain weather data for the public, cooperators and to support forecast operations. Station elevations range from about 3000 ft (914 m) to around 7,500 ft (2290m), with most exposed to the harshest of weather conditions. Sites and sensors must be designed to accommodate up to 30+ ft (10m+) snowdepths, 100+ mph (160+ km/hr) winds and temperatures below zero deg F (-19 deg C). While every effort is made to keep the data operating at most sites on a year-round basis, funding and staffing limitations result in some instrumentation and stations not being maintained in the late spring and summer. Prepared by Mark Moore, NWAC.

Lower Photo—NWAC forecaster Garth Ferber troubleshoots instrumentation at the upper Chinook Pass weather station on Knob 1 (elevations ~6800 ft, 2070m) to the ENE of Mt Rainier (in the background). Unheated wind speed and direction sensors are shown, along with the two tubular fiberglass shields that protect RF antennas from the debilitating effects of rime on the radio elements. The Rohn 45G 18-inch equilateral tower lies on a very wind exposed ridge and is supported by a 1000# concrete base and several semi-vertical steel struts that connect to smaller concrete bases. The site can act as a repeater for the more sheltered Chinook Pass RF precipitation/snowdepth site about ¼ mile to the south. However, intermittent RF problems have plagued the site during the recent past and a new RF base station (with direct line of site to the Knob) is planned this summer at nearby Sunrise within Mt Rainier National Park. Photo by Kenny Kramer, NWAC.

Northwest Weather and Avalanche Center

Mission Summary

The NWAC exists to:

Help reduce the impacts of avalanches and adverse mountain weather on recreation, industry and transportation in Washington, northern Oregon and southern British Columbia through data collection, forecasting and education.

NWAC promotes public safety by providing the public and cooperating agencies with:

- Public Avalanche Forecasts
- Snowpack Information
- Mountain Weather Forecasts
- Mountain Weather Data (current & climatological)
- Education
- Applied Research and Technology

Northwest Weather and Avalanche Center
2002-03 Annual Report

Table of Contents

List of Figures

List of Tables

SUMMARY AND MISSION STATEMENT

Mission—

The Northwest Weather and Avalanche Center (NWAC) promotes safety by helping reduce the impacts of avalanches and adverse mountain weather on recreation, industry and transportation in Washington, Oregon and southern British Columbia through data collection, forecasting and education.

To achieve this mission, the Northwest Weather and Avalanche Center:

- assists a variety of snow safety and snow maintenance programs by providing and analyzing useful weather, snow and avalanche data, and by producing and distributing a variety of mountain weather and avalanche forecast products.

- assists back country travelers by providing current information on snowpack structure and avalanche danger, and by forecasting expected changes in snow and avalanche conditions.

The professional mountain meteorologists and avalanche specialists at NWAC are on duty from September through June, issuing twice daily mountain weather forecasts and daily avalanche forecasts (more often as needed) from about mid-November through mid-April, with special statements as warranted in the early Fall and mid-late Spring.

Summary—

Administration

Since its inception, the NWAC has been administered by the US Department of Agriculture-Forest Service.

Funding

The Avalanche Center is cooperatively funded by a variety of federal, state and private agencies. Important cooperators include the Washington State Department of Transportation, Washington State Parks and Recreation Commission (Snowmobile and Snowpark Programs), National Weather Service, National Park Service, Pacific Northwest Ski Areas Association, British Columbia Ministry of Highways and Transportation, and others.

During it's research phase of operation in 1976-78, the Avalanche Center annual operating costs were ~$81,500, and these costs were shared by WSDOT and The Federal Highway Administration. This provided short summary weather forecasts for three major mountain passes and a short avalanche forecast for about 4 months/year.

In Fiscal Year (FY) 2000, annual operating costs were ~$245,000, for FY2001 ~$247,000, for FY2002 ~ $238,000, and for FY2003 ~$253,000 with decreased funding levels anticipated for FY2004. However, the program now provides detailed twice daily meso-scale weather and avalanche forecasts for all the Washington Cascades and Olympics, and northern Oregon Cascades—or together for an area larger than Switzerland. These forecasts are routinely available for 6 months/year, with spot forecasts prepared for the southern BC Cascades and Crater Lake area in Oregon as needed for 8 months/year. NWAC forecasters also prepare daily weather forecasts for WSDOT avalanche control and maintenance personnel for higher pass closure and opening operations in the early fall and mid-late spring.

The program also **manages the most comprehensive real-time mountain weather data network in the US.**

The total of Direct (actual revenues received) and Indirect (in-kind) contributions for the Avalanche Center in were ~$348,825 in FY98, ~$378,275 in FY99, ~399,000 in FY2000, ~$405,000 for FY2001, ~$399,000 in FY02 and $~$415,000 in FY03.

The Colorado Avalanche Information Center (CAIC) also provides forecasts and avalanche control / recommendations for the Colorado Department of Transportation (CDOT) for a series of mountain passes. CDOT support of the CAIC program for FY2002 totaled nearly ~$296,000 (contract, grant and in-kind; FY03 figures not yet available).

Housing & Location

The NWAC is housed at the National Weather Service Forecast Office in Seattle, Washington, at the Western Regional Headquarters of NOAA at Sandpoint. The National Weather Service provides in-kind contributions of office space, computer, weather and satellite data access, and dissemination services and has also contributed periodic capital equipment (weather sensors).

Staff

To help minimize cooperator costs, three professional avalanche/weather forecasters are employed for 9-10 months/year, with intern training programs being developed to help train new forecasters. Non-forecast season duties include planning and maintenance of the data network and related services (including web site development), program administration, education, cooperation with program cooperators, and data application of new weather and avalanche technology to meet program goals.

Direct Program Benefits—

Avalanche Accidents and Public Snow Safety

Soaring back country recreation during the last 30 years (skiing and then snowmobilers and snowboarders) has produced **an annual average avalanche fatality toll in the United States that has risen from 5-10/year in the early 1970's to approximately 30 deaths/year** (5-yr moving average), with 32 fatalities recorded in 1998-99, and 33 in 2000-01, 35 in 2001-02— all setting at the time unfortunate modern-day records (since 1950). This trend toward increased numbers of avalanche fatalities nationwide continued in 2002-03 with 30 fatalities reported through mid-May, 2003.

However, **in the Northwest the fatality toll has and has been declining slightly and now stands at an average of ~1.8/year** (5-yr total of 9 fatalities for Washington and Oregon from 1998/99-2002/03).

It is believed that avalanche education and forecasts have resulted in a significant reduction in both avalanche accidents and resulting rescue efforts and costs, hence stabilizing or reducing the number of avalanche fatalities despite major increases in winter back country use and recreation.

There are many documented instances where travelers canceled trips or rescheduled timing or locations of planned trips based on forecast information.

There is also significant documented evidence of popular public response to the program—while there has been a slow decline in phone access of forecasts, this decline has been more than made up for in dramatically increased access of forecasts via the Internet. NWAC Avalanche Forecast Hotlines log between 5 and 15,000 phone calls annually, with over **1.8 million hits** on NWAC avalanche and mountain weather products via the web during the past year (2002/2003).

Highway and Ski Area Maintenance and Snow Safety

Washington State Department of Transportation claims considerable annual savings through usage of the program.

WSDOT estimated that the **program saved the state approximately $180,000 in 1977/78 and over $330,000 in 1986/87 in direct maintenance costs, lower closure times and reduced public impact**. **More recently, a 1997 WSDOT study indicated that Puget Sound area businesses lose a total of $485,000 per hour of pass closure (for Snoqualmie Pass only), with an estimated $750,000/hour of lost revenues in 2001** (economist study, Seattle PI, December 2001). This means that a total of about 16 million dollars is lost by local area businesses for every day of I-90 pass closure (other concurrent pass closures would increase this figure). Such a figure underscores the economic importance of a reliable and accurate avalanche and mountain weather forecasting program. These figures do not include the increased safety margin for highway travelers owing to a more effective and responsive avalanche control and highway maintenance program.

The ski industry (PNSAA and NW ski schools) claim significant benefits in daily area operation, school and work planning, lift operations, and snow safety programs.

Forest Service personnel also allege more efficient maintenance and grooming of popular cross country and snowmobile trails as a direct result of NWAC forecasts.

Education

NWAC forecast staff presents a variety of avalanche, weather and snow safety seminars that educate the public and cooperators. During the last 5 years, over 10,000 people have attended avalanche and weather presentations by forecast staff and Friends of the Avalanche Center associates.

Applied Research

Forecast staff constantly tries to apply and advance state-of-the-art techniques in weather and avalanche science. To meet this goal forecasters attend a variety of training sessions or workshops.

Forecasters have also been instrumental in aiding advances in weather sensors and automated weather sensing techniques, as well as contributing significantly to methodology for avalanche and weather forecast dissemination.

To share these techniques and help expand avalanche and/or weather awareness, forecasters give a variety of presentations at International Snow Science Workshops, the National Avalanche School, and other weather and snow seminars.

Field Data

The NWAC plans, develops, installs and maintains the most comprehensive data network of its kind in the United States. A network of 38 remote automated weather stations at 16 separate sites (most sites consist of at least two or more sub-stations) telemeter hourly precipitation, snowdepth, temperature, wind and relative humidity data to the NWAC. Data from these stations is automatically linked to the NWAC web site in order to provide both the public (skiers, snowboarders, hikers, climbers and other recreationists) and cooperators enhanced access to real-time weather and avalanche-related data. The NWAC utilizes the mountain weather data to support more accurate forecasts, and cooperators utilize the information for planning, maintenance and avalanche control purposes.

WEATHER AND AVALANCHE SUMMARY

November

One of the driest October and November on record for the Northwest (especially Washington) greeted NWAC forecasters when they returned from ISSW2002 for maintenance of the data network and related instrumentation. October and November monthly water amounts for Seattle-Tacoma International Airport of .54 inches and 3.71 inches respectively (two month total of 4.25 inches) squeezed out less than half (45%) of the normal monthly amounts of 3.41 for October and 6.06 for November (two month total of 9.47 inches). And with the weather also being milder than normal, the small amounts of rainfall that were received in the lowlands at SEA-TAC (Seattle-Tacoma International Airport) were also rain in the mountains. As a result, the climatological snowdepths recorded on December 1, 2002 (see below in Climatology) set several minimum depth records of zero or near zero for that date.

December

After the mini-drought endured during the early-mid fall of 2002, the late fall didn't do much better and December didn't arrive with a bang or even a whimper. However, 2002 did depart with a bang as can be seen in the description below, and on the seasonal freezing level/precipitation charts for the winter. However, for most practical purposes, winter didn't really arrive at all in the Northwest until mid-late December, as much of the early season (late fall) storm energy split offshore and headed southeastward toward California and the southwest US. This flow pattern (a split jetstream) is common during El Nino winters and this winter seemed to fall in line rather well, with good storm activity and early season snowfall reported across much of the southern tier states. In fact, the early season storms broke the year long California drought in convincing fashion, with many suburban and city streets flooded by some of the heaviest rainfall ever recorded in some southern California locations for a 24-hour period. Further to the north, the first major storm cycle of the season occurred in the Northwest from December 14th-17th when 1-3 feet of snowfall were recorded at most sites including the normally significantly drier Mission Ridge along the Cascade east slopes. However, with upper and surface lows moving through the area much further south than normal (again the El Nino influence), this storm track favors generally heavier precipitation along the Cascade east slopes. In response to this first major storm activity of the season, the NWAC issued several special statements on December 12th and 13th and then opened for normal operation on the 14th. With this abrupt transition from fall to winter, Washington Pass closed on the 16th of December when several avalanches hit the highway with 10-12 feet of snow reported at centerline of the Liberty Bell Paths #2 and 3. Cayuse and Chinook Passes closed shortly thereafter as snowfall continued through the 15th and avalanche releases were reported on control from Mt Baker, Crystal Mt, and Mt Hood Meadows. By the 17th, some of the earlier stabilizing vegetative and other terrain anchors had begun to be covered at higher elevations, and skiers and snowboarders triggered 2-3 ft slabs at both Mt Hood Meadows and Mt Baker. Fortunately no injuries resulted.

As a broad deep upper low moved onshore later that week (the 18th-20th) most of the flow and main energy with the storm track again took a bead on California, where some 9 ft of snow were received in parts of the Sierra Nevada during a 3-day period. This allowed for accumulation of either lighter low-density snow layers (in the southern areas closer to the upper low) or formation of some surface hoar (initially more northern areas and then all areas over the 21-23rd). Although some vegetative and other terrain anchors persisted below 3 to 4000 feet where a shallower snow pack remained, this set the stage for a significant increase in the avalanche danger and decrease in snow stability when loaded by heavier snowfall expected around Christmas. And arrive it did, with some 2+ feet of snow (29 inches) reported near Mt Baker and 14-20 inches in the Olympics. This prompted the first high avalanche dangers of the season, with "Avalanche Watches" issued for several areas on the December 26th forecast. Though other Cascade areas received slightly less snowfall with the stalling front on the 25th, the resulting burial of the aforementioned weak layers produced shooting cracks of 20 or 30 feet (Mt Hood Meadows above about 6000 ft) and many sympathetic and otherwise very sensitive slides that released to 12 to 14 inches deep on north exposures near Mission Ridge above about 6000 feet.

Late on the evening of the 26th and continuing through much of the 27th a strong frontal system moved over the area, accompanied by moderate to heavy precipitation, rising freezing levels and very strong winds. Ridge top winds gusted to over 100 mph at several sites on the morning of the 27th, including maximum gusts of 127 mph at Timberline (7000 ft), 128 mph at White Pass and 108 mph at Crystal Mountain, with the strong winds spreading northward during the afternoon, though not quite as strongly. Meanwhile, snow

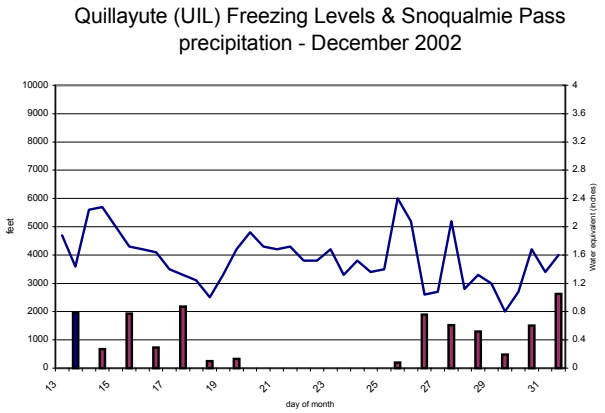
changed to rain at several locations extending briefly up to about 6000 feet in the south and 4000 ft in the north. All of this led to the first avalanche warning of the winter season, with high danger developing in a variety of areas along with some natural slide releases. Fortunately due to the anticipated high winds, several ski areas did not run upper chair lifts on the 27th, and just maybe this prevented skier or snowboarder access of unstable slabs adjacent to the ski areas.

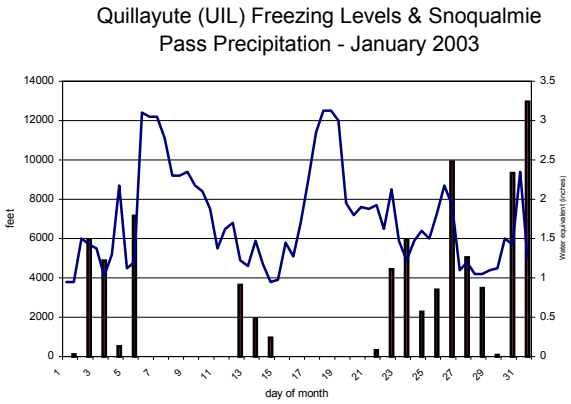
Another moderate upper trough and associated cold front raced across the Northwest on the 28th, bringing additional light to moderate snowfall at low freezing levels and generally decreased winds. This allowed some ski areas to access and control areas that had not been touched for two days and the results were dramatic—at least in some areas. For instance, during avalanche control on the 28th Crystal Mountain pro patrollers released several large hair trigger avalanches merely by skiing up toward the slopes, with some releases of the cohesive slab propagating upslope into 20° terrain. Subsequent investigations of the fracture layer indicated that buried surface hoar was the culprit in most of the releases. The buried surface hoar remained a problem at least through the 30th of December, with Mission Ridge ski area reporting a narrow skier escape from a surface hoar related 2 ft x 60 ft slab on the 30th (from a relatively low angle—25° slope in-area).

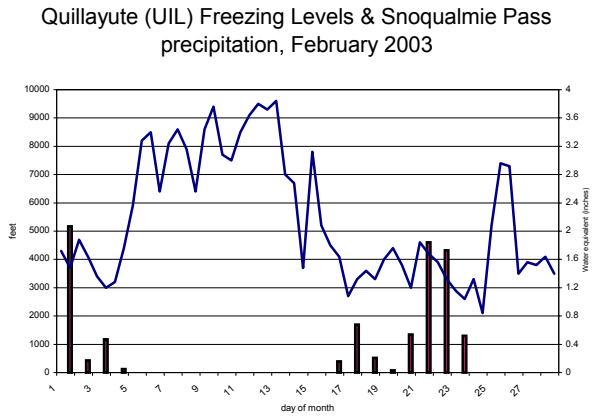
Unfortunately the powdery new snow that brought some excellent skiing and snowboarding conditions to the region masked the still lurking weak layers underneath a harder slab that the winds on the 27th produced. This set the stage for the 1st avalanche fatality in the Northwest since the winter of 2000/01. This accident is described in more detail in the preliminary report available on the NWAC web site, but in summary involved a group of seven skiers—both telemarkers and alpine tourers—that headed up into the backcountry northeast of Crystal Mountain on December 29th. Partial clearing and light showers greeted the group as they headed upward toward Cement Basin on the northeast side of East Peak. After skiing good powder on a gentle ridged slope from the saddle north of nearby Platinum Peak without incident, the group then decided to ski a more challenging bowl just east of the first run. The first two skied the slope beneath Platinum Peak without problems into and through the narrow hourglass shaped drainage near the bottom. Then three members of the party began skiing the bowl while the remaining two finished a hike to enter the bowl from a higher and steeper vantage. Upon entering the slope, the last skier to enter the slope triggered a 1-2 ft deep x 200 ft wide slab that caught four of the group, partially burying three and one totally after running about 500 ft vertical. After the remaining members of the party extricated themselves from their partial burial (three were partly buried), and briefly attended to one of their injured (a broken lower leg), they immediately commenced a beacon search for the remaining lost party member. While all party members had beacons, probes and shovels and a quick (15-20 minute) search and recovery followed, the totally buried victim did not respond to the group's CPR efforts, and he was pronounced dead at the scene by a doctor within the group. Although the victim was found about 5 feet deep in a face down position near a tree and had sustained a bruised forehead, subsequent autopsy indicated that suffocation and not trauma was the cause of death. While any accident like this is a tragedy, such an accident reminds us of why we are here and what we are trying to prevent.

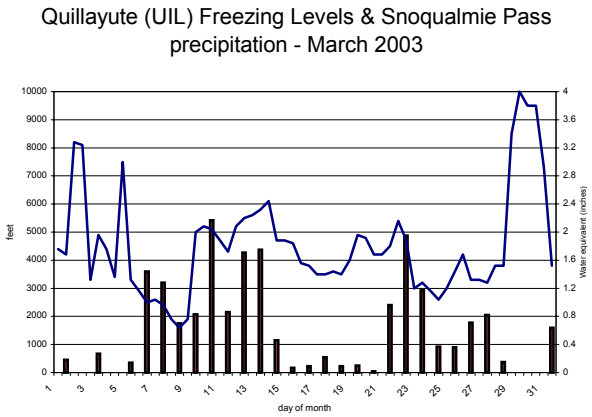
A strong southwest flow ahead of a deep broad upper trough in the central and eastern Pacific carried another frontal system across the Northwest late on the 29th through morning of the 30th, with considerable showers following the front on Monday afternoon. Along with increasing winds new snowfall amounts reported on the 30th ranged from 5 to 13 inches with another 5 to 13 inches reported on the morning of the 31st. Along with strong winds with both disturbances, significant wind slabs developed over a variety of buried weak layers that included the aforementioned surface hoar, low density snow and graupel. Although a weak and flat upper ridge brought deceasing showers and some brief clearing on the 31st along with some increase in easterly winds, a very strong jetstream moving under the offshore trough moved over the top of the retreating flat ridge and brought an increasingly strong series of generally warmer and wet storms into the region from later on the 1st through the 4th. The following figures show a graphical depiction of the evolution (or non-evolution as seemed to happen for much of this past winter) of the winter as it is discussed both above and below.

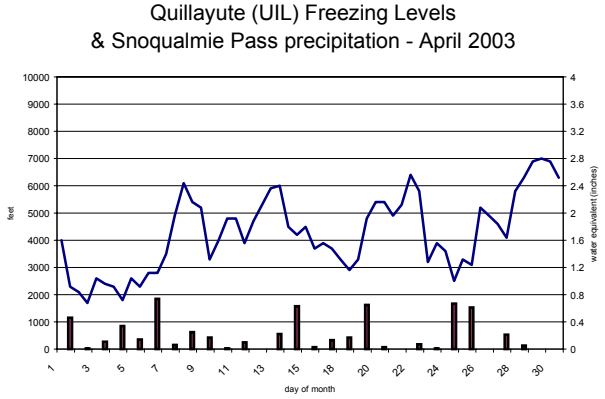
Figure 1. Twice daily Quillayute freezing levels and daily Snoqualmie Pass precipitation--December, 2002 - May, 2003

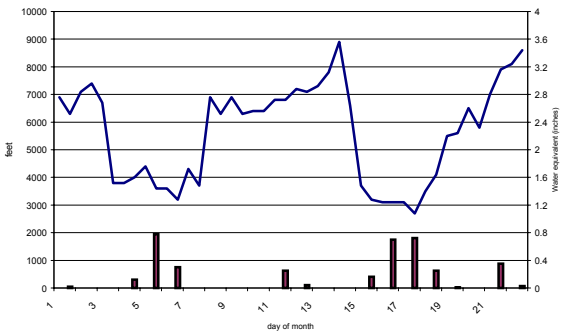












January

Opening up the New Year in a dramatic fashion, Mt Rainier National Park reporting another narrow escape from another surface hoar related slide near Paradise on the 1st of January. In this incident on a 30-35° SW exposure slope at the 6200 ft level, two snowshoers were traversing the switchbacks on the Golden Gate trail as they climbed toward Mazama Ridge to the NE of the Paradise Visitor Center. From an eyewitness report, the party released a 2-4 ft slab that caught the shoers and carried them about 75 ft slope distance, partially burying one and totally burying another, with only a hand sticking out. The totally buried victim was subsequently found and uncovered by her partner and a nearby party using snowshoes for shovels (neither this party or the nearby party had beacons, shovels or probes).

Following this incident, the first significant storm of the year moved into the region mid-late day on the 1st, welcoming in the New Year of 2003 with high winds (gusting over 110 mph in several areas), heavy precipitation and high freezing levels. With snow changing to rain overnight on the 2nd, this prompted issuance of an avalanche watch on the forecast for the 1st and a brief warning on the AM forecast of the 2nd. Significant natural and controlled slides were reported on both days—some ranging up to 4 feet deep on wind loaded terrain. At least the warming and heavy loading helped to begin snow pack settlement of the 2 to nearly 5 feet of snow that had been received in most areas since Christmas, and the resultant crust began to bridge over any remaining buried surface hoar that had not already released in the many slides being reported. Although brief ridging and cooling on the 3rd produced decreasing avalanche danger as the crust began to strengthen, heavy rain, high freezing levels and strong winds late on the 3rd through early on the 4th brought an increase in the danger as rain or wet heavy snow weakened or loaded near surface snow, increasing the probability of wet loose or isolated wet slab avalanches at lower elevations and some high density wind slabs above about 6000 feet. Finally, following brief moderate to heavy snow showers, lowering freezing levels and strong winds mid-late on the 4th, the recent strong and dominant zonal flow began to buckle, bringing increased ridging over the area and lifting the jetstream and heaviest precipitation northward into south central BC on the 5th and 6th. While weakened southern storm remnants of the almost stationary frontal boundary moved over southern BC on the 6th and 7th, most Northwest areas experienced mostly sunny and unseasonably warm weather for the first time since early December. Unfortunately the great weather arrived too quickly to allow for significant snowfall to accumulate over the old refreezing and rain-soaked surface snow in most areas and a strengthening crust brought its own injury danger from uncontrolled and fast sliding on its unyielding surface. Also, while daytime temperatures rose into the mid-upper 40’s and low 50’s in most areas west of the Cascade crest (freezing levels reached up to 12,000 feet in the north and 14,000 feet in the south), an increasingly cool easterly surface flow along with increasing low level moisture along the Cascade east slopes brought a rather drab pattern of much cooler temperatures, low clouds, freezing fog and isolated flurries to most areas below 3-4000 ft east of the Cascade crest. This fair weather also brought with it significant surface hoar growth over the developing crust in many places—and any places that this weakness is buried intact will bring a dramatic increase in avalanche danger with subsequent storms. Finally the period of colder weather at lower elevations near and east of the Cascade crest brought some faceting and overall weakening of the generally shallow snow pack structure—a factor that could become important and allow slides to reach buried weak layers or the ground if future heavy loading occurs.

The crusts and weak layers just above the crust came into play in terms of the avalanche danger when the long-blocking upper ridge briefly broke down from the 11th-13th and allowed several moderate frontal systems to move through the region along with the associated moderate upper trough. Although initially this brought rain to lower-mid elevations from the Cascade crest westward and in the Olympics, a cool easterly surface flow protected the Cascade passes and east slopes from the warming aloft, thus producing mostly snow—and the heaviest in some time—near the passes and at higher elevations. This increasingly dense wind slab snow was deposited over either the old crust, shallow amounts of faceted or recycled snow above the crust, or surface hoar, with the resulting slabs being reported as relatively sensitive and quickly running relatively long distances—even though still prevalent vegetative anchoring in the lower parts of many paths prevented really long slide runouts. A considerable danger was forecast for many areas at this time with generally shallow but rather sensitive wind slabs probable. Also during this episode some field reports indicated shooting cracks propagating out 50-100 feet ahead of skis, along with significant localized snow pack settlement or whumpfing—this near Blewett Pass on the Cascade east slopes. Several professional ski patrol reports also indicated very sensitive skier and explosive released avalanches along with significant natural slide activity.

Almost spring like freezing levels blanketed the Northwest during the middle part of

January with only a brief two-day stint of increasing rain or snow in the middle of the month. Then the almost resident and relatively strong blocking ridge returned to the region producing relatively dry and cool conditions near and east of the Cascade crest (a cool and moist easterly surface flow brought trapped low level moisture westward toward the passes), but warm and dry conditions at higher elevations, in the Olympics and along the Cascade west slopes. However, while air temperatures soared into the upper 40's and 50's on many of the days above 5 to 6000 feet, this clear weather produced a lot of radiational cooling at the snow surface and significant deposits of surface hoar were seen on shaded terrain both sides of the crest along with some faceting and re-crystallization of the snow pack both just below a surface crust and just above the mid-January crust. When heavy loading of these weakened layers arrived in late January (with more substantial snowfall near and east of the crest due to the initially cool easterly flow), this brought a significant increase in the danger, with the first slides of the season reaching the highways at both Stevens and Snoqualmie Passes, along with many natural, human and explosive triggered slide releases. Fortunately during this surface hoar episode no one was injured in the Northwest. Unfortunately though, the relatively weak snowpack structure that developed locally was also found in the interior ranges of southern BC, and when some heavy snow loading moved over the top of the ridge across the southern Canadian Rockies near Revelstoke much more dire results ensued. Guests of the back country oriented Selkirk Mountain Adventure felt the wrath of winter in a relatively small (100 ft across by 300+ feet vertical fall distance) but catastrophic slide (in consequences) that caught 14 back country skiers and snowboarders and killed seven on the 20th of January. Another catastrophic BC avalanche released a week and a half later from Mt. Cheops, about 20 miles to the east of the previous accident above Rogers Pass, running about a mile and over 2000 feet vertical. The natural slide apparently began as a rather small slab high on the northeast flanks of the mountain that subsequently triggered a much large slide about mid-path on the slope. After running down to the valley floor, the slide apparently split into two nodes, one running across and up the other side of the valley and the second making a rather sharp turn down valley. After traveling an additional ¼-½ mile (approximately 400 m), the slide engulfed and caught some 17 skiers participating in a school field trip, burying 15 and eventually claiming 7 lives. Official reports on these accidents should be available on the Canadian Avalanche Center (www.avalanche.ca) web site once they become available.

A series of relatively warm and moist weather disturbances then rode on the west to southwest flow around several upper lows to bring more moderate to heavy rain to most Cascade locations near and west of the crest from the 20th through the end of the month. This brought some local flooding along the southern slopes of the Olympics while presenting an interesting snow pack that resulted in some wet loose or isolated wet slabs that reached the mid-January crust. Fortunately, with so much rain arriving during the month (almost 75% of the 12 inches of WE received in some areas arrived as rain), good percolation channels became established in much of the snow pack below about 4000 feet and this helped to quickly drain liquid water from the surface snow and limit the avalanche danger.

More wet southwest flow connected to subtropical air arrived on January 30th and 31st. Freezing levels rose to around 7000 feet in the north and 10,000 ft over Mt Hood. Storm water totals as of the afternoon of the 31st were 3 to 4.5 inches and climbing! Since the 21st of January, Stevens Pass received about 14 inches of water! While this brought an end to the drought, unfortunately most of the precipitation fell as rain. Natural avalanches were heard and seen both at Stevens and Snoqualmie Pass early Thursday night (the 30th) as snow changed to rain. However, on the 31st, the snow pack was draining the water efficiently through established drain channels and this prevented more significant avalanche activity. Actually, with all the water received over the last two days, overall avalanches were more limited than normal due to a very rainy few weeks preceding these most recent heavy rain events.

February

Cooler weather arrived in early February as several weak disturbances passed over the top of building offshore ridging and brought some 5-20 inches of snow above 4-5000 feet. Also moderate west winds built some slabs on east and southeast exposures with some weak layers reported near the relatively thick rain crust from the end of January and early February. As a result the Avalanche Center received some reports of backcountry skiers avoiding some slopes. Unfortunately, the drought returned in earnest during the early part of February, and a high amplitude upper ridge just offshore resulted in mostly clear dry weather from the 4th through the 13th of February. Radiational heat loss from the snow surface during the clearing allowed extensive 1-2 cm hoar frost and increasingly weak faceted snow to develop above the recent crust on northeast to northwest facing slopes and other shaded terrain, with reports of small loose avalanches of the weak faceted snow on steeper shaded terrain. However, warm daytime temps and cool night temperatures resulted in gradually stabilizing surface crusts on sun exposed slopes and at lower elevations, with some 8-10 inches of settlement observed during this time at sites such as Mt Baker, Stevens Pass and Paradise. This produced a highly

variable snow surface prior to some light rain showers at high freezing levels on the 14th, which produced even more snow pack variability before snowfall and lowering freezing levels arrived on the 15th. Finally in some wind-exposed areas, several episodes of increased winds during the clear weather early in the month scoured the loose snow down to the crust, producing a smooth sliding surface for future snowfall.

With increasing light to moderate snow, lowering freezing levels and increasing winds occurring with a frontal system mid-late on the 15th followed by moderate to heavy showers and further wind transport on the 16th, the avalanche danger increased significantly with great caution advised as the snow pack stability was expected to be highly variable and even multiple stability tests might miss the developing danger if not done in places where surface hoar or faceted snow lingered. Unfortunately, in places where these weak layers were buried intact they should be slow to sinter and could be potential weak layers for some time to come.

Almost normal winter like weather returned to the Northwest in mid-late February, with some 20-60 inches of snowfall received late on the 16th through the 23rd as several moderate to strong weather disturbances tracked over the region and the recently dominant ridge weakened and moved east. It is fortunate for snow pack stability that much of this initial precipitation was accompanied by variable and rising freezing levels and some rain, as the rain or high density and high intensity snowfall helped destroy or settle and refreeze much of the surface hoar and build an increasing higher density bridge over the previously faceted snow. Hence while a significant increase in the danger accompanied this new snowfall, and ensuing instabilities produced a lucky avalanche incident on Mt St Helens on the 16th and caught several ski patrollers at Alpental ski area on the 20th (during a rapid rise in freezing levels), the previous weak layers did not produce nearly the instability that could have developed if only snowfall had been received. In most instances, much of the greatest instability was found at higher elevations where the rain had less of an effect. Nevertheless, the series of storms produced considerable to high danger for over a week above 4 to 5000 feet, and several skier triggered slabs were reported with sympathetic slides reported in several areas and substantial shooting cracks of over 50 feet reported near Mt Hood Meadows on the 22nd. Finally the main upper trough moved over the region later on the 22nd and 23rd, bringing the long sought after cooling and a generally stable density profile. However, substantial shower activity were accompanied by strong winds that developed increased danger on southeast through northeast facing slopes, where initial and locally high danger gradually declined to considerable by the 23rd. Northerly flow following the trough brought clearing skies to most areas, but then a second trough sent modified arctic air and a weak arctic front southward along the Cascade east slopes. This resulted in the coldest temperatures of the season, with temps plummeting to single digits or below (several areas reported temps reaching below zero readings) and strengthening east to northeast winds accompanying and following the arctic front. This brought wind chills to well below zero, but more importantly it produced significant transport of loose surface snow onto west and southwest exposures where a considerable danger developed from relatively shallow (mostly 1-2 ft) slabs overlying either lower density snow from the previous day’s shower activity or isolated areas of surface hoar.

Clear, cold weather with strong winds on the 24th helped to maintain the locally considerable danger while scouring and stabilizing the snow pack in wind exposed terrain. A backcountry skier just outside the controlled area of the Crystal Mountain south backcountry experienced first hand evidence of this wind transport Monday the 24th when a 30 cm hard slab was triggered on a NNW facing slope at about 6600 feet. The skier fortunately was not hurt and subsequent investigation by the Crystal Mountain ski patrol on Tuesday the 25th revealed the 30 cm hard slab over lower density snow deposited last weekend. A compression test score of 3 taps yielded an easy failure at the interface of the wind slab and lower density underlying snow producing a very clean shear or quality one.

As the offshore ridge leaned over BC on the 24th and over the Northwest on the 25th, decreasing winds and some slow warming allowed for a slow decrease in the danger even though some shallow slabs persisted and their bond to the underlying harder layers weakened through the faceting process. While several weak disturbance tried to penetrate the newly developing ridge on the 26th-28th, associated fronts tended to split and weaken with most energy directed either well to the north or south of the area, with the main impact being periods of increased clouds and some periods of relatively light snow at slightly moderating temperatures and generally light winds. This relatively benign weather allowed recent wind slabs to continue to slowly settle and stabilize with an increasing surface sun crust developing on sun exposed terrain and slow faceting continuing near older higher density crusts, especially near the mid-February crust. Although little or no precipitation was received over much of the Northwest, circulation around closed and cutoff lows that moved to the south under the ridge brought moderate to heavy precipitation to much of the southwest US during the week of the 24th-28th.

March – in like a lamb out like a lion

While March weather began benign enough—a weak disturbance on the 1st and 2nd brought additional light snowfall and yet another upper ridge and associated dry northerly flow brought clearing skies on the 3rd and 4th, the upper level flow pattern changed appreciably later on the 4th and 5th. This change was sparked by the increasingly strong westerly flow around the base of a deep upper low that retrograded and developed over northern Saskatchewan and Manitoba. The resultant westerly flow was compressed between the upper low and a southern branch of westerlies that spread under a retreating and closed upper high over north-central Alaska. In any case, the very strong westerly jetstream picked up moisture over the northeast Pacific and the resultant hefty orographic flow then shoved it into the Cascades and Olympics on the 5th and 6th produced copious snowfall in many areas—all at unheard of low freezing levels for the current winter. As a result, 24-hour snowfall totals of 20-36 inches were being reported with sustained 3-inch/hour snowfall observed for 10-12 hours at a stretch. If not combined with only moderate winds and lowering freezing levels, the developing new snow pack and wind slabs would have been much more unstable than they otherwise were. Still, a generally high danger developed above about 4 to 5000 feet and the first sustained avalanche warnings of the season were issued on the 5th-7th of March. Field reports indicated that human and explosive controlled avalanches were easily released in most areas, however most were direct action or storm related slides and primarily involved only the most recently deposited snow as the low temperatures and lack of dramatic winds prevented a really cohesive snow surface and the existence of a relatively deep weak layer (consisting of much of the new snowfall) prevented stress concentrations from building up within the new snowfall. However, there were sporadic reports of slabs releasing on either the surface hoar that developed under clearing skies early in the month (the evening of the 3rd) or the faceted snow near the old rain crust from mid-February.

However, a significant and warming trend overnight on the 8th through the morning of the 9th seemed to provide the one main ingredient that had been lacking in order to have really substantial slide activity—this was a cohesive slab. When this arrived, the danger progressed dramatically along with a higher percentage of large slabs releasing down to the old crust. The first large release was reported by the Mt Hood Meadows ski patrol on the afternoon of the 8th when they released a 15-foot crown slab with a 5 lb charge in an area that generally does not avalanche large. By the morning of the 9th, some 3-7 feet of new snow had fallen over the prior four days and some slab depths likely twice that deep lay waiting on a variety of lee slopes for the increased stress that would accompany the warming, higher density, more cohesive, and rapidly creeping slabs that were expected along with some rain at lower elevations later on the 9th.

Given the above conditions, the first extreme danger level warning of the season and indeed in over two years was issued on the afternoon of the 8th to cover the warming and heavy precipitation that arrived overnight and early on Sunday the 9th. The extreme danger level warning was continued for all areas except the Cascade east slopes for the forecast issued on the morning of the 9th, with an avalanche warning for high danger along the east slopes where a little less new snowfall had been received. The following email received by the Avalanche Center partly indicates some of the dangers that occurred during the warning situation—this narrative involving some snowmobilers just east of the Cascade crest:

> *"Just wanted to let you know that I witnessed several slab avalanches on Sunday the 9th in upper Gale Creek basin. T22N R12E Sec. 35 NW corner. This area is accessed by groomed snowmobile trail, Forest Rd. 4948 and is a popular route from Kachess Lake Snopark that takes riders into the Keechelus Ridge/Baker Lake country. At approximately 11:30 am, two slides approximately 1.5'- 2' broke from fracture lines and created 10-12' deep debris fields right on top of the groomed route. My co-worker Colby L. and I had made the determination to turn around due to ominous signs and conditions that morning. As we were turning around, we stopped 4 snowmobilers to ask them to turn back. They agreed, but in the short time period they were turning around, a slide came down, flipping a snowmobile onto its hood and breaking the riders nose. The sled was partially buried, but luckily the rider was not. We quickly dug the sled out, and got everyone out of the area. We stopped along the route outside of slide paths, and had to cross one more debris field to get out of the exposed part of the basin. There were cracks all over the basin, and approximately 4 runs. The slide that came down on the snowmobiler was a NW exposure, and the other slides were on SE exposures. Any questions, just e-mail me for more information."*

Following the dramatic danger increase associated with the major warmup and rainfall, a generally weaker west to southwest flow over the top of flat offshore ridging brought several weaker weather systems toward the Northwest as a deeper low moved slowly eastward in the western Gulf of Alaska. This produced several days (10th and 11th) of smaller snowfall amounts at intermediate freezing levels along with intermittent rain at

lower elevations. However, later on the 12th a strong front moved toward the coast as the deepening offshore low forced the ridge eastward. While the trough deepened further offshore, this stalled a stationary front over the region with substantially rising freezing levels and locally heavy precipitation from about Mt Rainier northward, heaviest in the Olympics and north Cascades. Two day precipitation totals on the 12th and 13th ranged from about 2.5 inches WE at Mt Rainier to almost 4 inches at Crystal Mt and over 8 inches at Mt Baker. Although this produced a return to generally high danger at higher elevations along with some large avalanches from Mt Rainier northward, significant melt water channels had already been established at lower elevations during the earlier heavy rain event on the 8th and 9th and this helped reduce both the danger and the amount of avalanching at mid and lower elevations.

After the associated upper trough deposited moderate amounts of new snow over the developing crust late on the 13th into the morning of the 14th, a generally weaker flow with several splitting weather disturbances at intermediate freezing levels from the 15th-19th allowed the most recent wind slabs to begin settling and the generally wet upper part of the snow pack to begin refreezing and strengthening. This finally but briefly dropped the danger into the low to moderate range as minor new snowfall amounts and some clearing overnight allowed for less significant slab formation along with some surface hoar. However, despite the settlement, some shallow wind slabs were still generated at higher elevations, and snowboarders touring in the Mt Baker backcountry triggered several 6-12 inch slabs.

Although the calendar began to signal a close arrival of spring, another series of storms arrived late on the 20th of March lasting until the 27th of March. About 2-6 feet of snow accumulates at higher elevations. The first storm moved through still cool air behind the last disturbance and produced moderate to heavy snowfall at relatively low freezing levels into the morning of the 21st, with up to 6-13 inches of relatively low density snowfall reported by 4 AM, and another almost 8 inches reported during a period of 2-3 hours during the morning of the 21st at Stevens Pass. While some areas reported lighter amounts of new snow, rather sensitive slides were reported running on the recent crust. By mid-late afternoon on the 21st, another stronger disturbance brought considerable warming and increasingly strong winds to the region through the morning of the 22nd. This upside down cake produced a highly unstable snow pack over several old crusts with weak layers including buried surface hoar and low density snow from earlier in the week. As a result an avalanche watch was issued on the morning of the 21st for significantly increasing danger.

The next significant storm to move over the region lasted from the 25th-27th of March with low snow levels allowing 1-2 feet of snow to accumulate near and west of the crest. During this storm episode a skier was caught by a 1-foot self-triggered slab avalanche at the Crystal Mountain ski area, and this resulted in significant injuries as he was swept into and pinned against some trees by the sun-warmed heavy snow that had developed during the day. Apparently in this incident, although the victim was not totally buried, he was about to lose consciousness before either friends or the patrol arrived and relieved the snow load that was keeping pressure on his chest in his wrap around the tree. Also during this weather situation, unexpectedly heavy convergence greatly enhanced local snowfall at Stevens Pass late on the 26th with almost .7 inches WE and 8 inches new snow in a little more than three hours(15 inches in the 24 hours ending on the morning of the 27th).

The first major warm period of the spring arrived on the 29th and 30th of March as a strong warm front brushed Washington and then the following cold front stalled offshore as the associated upper trough deepened offshore and several impulses brought locally heavy rain and snow to the central BC coast. This resulted in much of the Northwest being in the warm sector between warm and cold fronts, with the freezing levels rocketing up to around 10,000 feet. This produced significant numbers of wet snow avalanches and the first spring avalanche cycle. The warming and strong sunshine produced substantial cornice falls of the most recently received snow and wet loose slides gouged down into 1-3 feet of the upper part of the snow pack, triggering some wet slabs ranging from 2 to 3 feet deep. On Saturday, the 29th, a lone skier either triggered or was caught in a wet snow avalanche on Granite Mountain. The ensuing ride resulted in serious injuries, including a punctured lung and numerous broken bones. Fortunately a hiker came across the slide, helped the victim and used a cell-phone to alert search and rescue. After search and rescue operation commenced, the victim was airlifted to Harborview Medical Center for treatment of the injuries. Following the warming episode over the weekend of the 29th-30th, the cold front finally moved onshore and brought moderate to heavy rain overnight on the 30th of March, especially in the north Cascades where almost 2 inches of WE was received. This warming and rain produced further natural wet loose and wet slab slides, with slides reaching the highway at still closed Washington and Chinook passes, and stopping just above the highway at Stevens Pass.

Unfortunately, winter did not end as the calendar turned to April, and a very deep and

unseasonably cold upper low followed the cold front of the30th and moved into the Gulf of Alaska on the 31st of March and 1st of April, bringing increasing showers and increasingly cold weather. The low and several disturbances rotating around the low then moved over the region during the week of the 2nd-5th, bringing 1-3 feet of snow at low and lowering freezing levels. As freezing levels slowly rose over the weekend of the 5th and 6th, this created increasingly unstable wind slabs in several areas. Both a long term professional ski patroller at Mt Hood Meadows and a search and rescue group on Mt Rainier were surprised by the sensitivity of the ensuing slabs, one taking an unwanted ride.

April — the rejuvenated winter continues

Very cool weather with snow showers occurred throughout much of the month, starting during the week of April 1st-6th. The very low freezing levels (generally below about 2000 feet much of the week) allowed the recently wet upper part of the snow pack to refreeze into a crust in most areas at lower elevations...reported to be thin at the relatively high elevation (6-7,000 ft) Knob 3 near Chinook Pass (reported by the WSDOT highway avalanche crew on the 3rd). This substantially reduced the danger from the old wet snow pack, with new snow accumulating over the crust and most current slides confined to the new over the crust. Several inches of snow were received each day during this period with the greatest amounts in the volcanic peak areas and near Chinook Pass. Amounts for the week totaled up to about 3 feet on the volcanic peaks and about 2 feet at Snoqualmie Pass and at Crystal Mountain. Other amounts included 15 inches new at Mt Baker on the morning of the 4th of April, and 15 inches at Paradise and Timberline and 14 inches at Mt Hood Meadows on the morning of the 6th.

By April 3rd at Chinook Pass, some 12 inches of new snow overlaid the thin crust and daytime warming allowed the DOT avalanche crew to easily initiate wet snow avalanches. These slides were reported to gain much velocity and entrained significant snow as they descended, creating some rather large slides. A 2-3 fracture was seen by back country skiers on a 40-45° southern exposure slope on the 4th near Mt Baker, probably caused by sun effects.

A warming trend on the morning of the 6th and the recent heavy new snow received from Mt Rainier to Mt Hood helped produce easily triggered soft slabs, both natural and artificially induced. Extensive 1-2 foot skier triggered soft slab avalanches were reported Sunday morning by the Mt Hood Meadows ski patrol. A group of 3 hikers was reported lost late on the 5th of April near Paradise. Searchers on the morning of the 6th reported easily triggered small soft slab avalanches of 6-8 inches along the road to Paradise that morning and signs of instability during the search. Fortunately the lost hikers were found uninjured on the Nisqually Glacier moraine later that morning.

A large upper level low center became established well off the Washington coast around the 8th of April. This provided increasing southerly flow aloft over the region causing rising freezing levels and generally light amounts of precipitation of mostly rain each day, with the exception of locally heavier precipitation over Mt Baker on the 10th and 11th. The warming and light rain allowed for the recent snowfall to become wet and weak. Field reports from the Chinook Pass avalanche crew (detailed there from Snoqualmie Pass)on Wednesday and Thursday the 9th and 10th of April indicated that 12 to 24 inches of wet snow was available to slide, and some of it did. Both natural and triggered wet slides were seen during the later part of the week. One small wet sluff was observed from the highway and this slide quickly entrained significant wet snow as it descended then pulled out a 2 to 3 foot+ slab lower in the track. The slide hit the road with fury crossing about 100 feet in front of the observers before racing to the valley floor! A close call! Several other very large slides were triggered with explosives above the highway. Cooler temperatures overnight on the 10th and 11th allowed for a surface crust to develop, helping to limit the avalanche potential. However, this seemed to be only a relatively temporary reprieve as the deeper wet snow that was insulated by the surface crust was only waiting for further warming to again cause the potential for larger and deeper wet snow avalanches. However, with a series of unusually cool upper lows moving over the region during the remainder of the month, only sporadic larger wet slabs were reported.

Large deep but weak upper trough moved slowly southward over the Northwest coastal waters April 13th to 17th with another closed upper low quickly following it from about April 21st to 25th. This series of upper lows caused cooler temperatures and generally light precipitation with the heaviest precipitation moving onshore over California and the Sierra Nevada, where record setting April snowfalls were reported. New snow ranging from several to about 6 inches were received at Paradise and Mt Hood on the 12th and 13th. One 6 inch skier triggered soft slab occurred at Mt Hood Meadows 14th of April in the upper part of “A zone”. Despite the continuing small amounts of new snowfall, increased avalanche control on the major paths affecting the highway allowed for opening of Washington Pass on the 14th. Further generally light amounts of new snowfall continued from the 15th-17th, with another 4-8 inches added to the snowpack. While some

larger wet loose slides and isolated wet slabs released during afternoon warming and some brief clearing on the 18th and 19th (see the photo of one such event below), overall relatively little avalanche activity resulted owing to the continuing generally cool and showery weather and continued low freezing levels. With more cool and showery weather accompanying a series of weak disturbances rotating around yet another closed upper low moving slowly southeastward over the area from the 21st-25th, most slides at this time were limited to generally small near surface releases, and with no unusual weather or avalanche conditions developing and a weak flow continuing, the Avalanche Center closed regular daily operation on April 20th with Cayuse Pass opening for the spring on the 25th.

May—

The cool showery pattern continued in the Pac Northwest through the remainder of April and into May as one closed low followed another around an unusual blocking pattern for mid-late spring. Following a closed low that developed just off the coast in late April, a closed high moved into the Gulf of Alaska and this produced a strange slightly cyclonic northerly flow over the region. Several disturbances in this flow continued to maintain a weak to moderate upper low presence just offshore, with low snow levels and an associated frontal system depositing about 4 to 14 inches of new snow over the weekend ending May 5th, with greatest new snowfall over the Mt Hood area. Although new snow was available for typical spring time warming related avalanche activity, unusually cool temperatures through much of the week maintained mostly firm hard near surface snow conditions with very limited avalanche activity reported, especially in the Chinook Pass area where daily reports were received during the Monday-Thursday work week (May 5-8).

With a slow warming trend forecast through the following weekend of the 10th-11th the decision was made to keep Chinook Pass closed due to an increasing potential for avalanches. This seemed to be a wise decision, with reopening once again expected for the following week after the new snow had a chance to slide with considerably warmer temperatures and higher freezing levels expected to accompany weak ridging on the 12th and 13th of May. Still, no special avalanche statements were issued, as the situation was deemed rather normal for a Northwest spring. Most of the warming was quite slow and much of the recent new snow had several days of decreasing showers and slowly rising freezing levels to gradually stabilize through either settlement, melt or mainly small slide releases before the more significant warming late on the 12th and the 13th. Nevertheless, Chinook Pass avalanche crew reported significant wet loose slides releasing during explosive control and from ski cuts on both the 12th and 13th. Then as seemed to be the case for most of this spring, a gradually strengthening upper trough quickly followed and moved toward the NW coast on Wednesday the 14th, with gradually increasing precipitation moving onshore along with several upper disturbances later on the 14th through the 16th that brought dramatically lowering freezing levels and increasing ridge top winds. Despite the anticipated new snowfall and because of increased pressure to open the highway, Chinook Pass opened for the spring on the afternoon of the 15th of May. However, owing to new snowfall and winds on the 16th-18th followed by rising freezing levels and some clearing during the week of the 19th-23rd, WSDOT avalanche crew maintained a daily presence at the pass over the weekend of the 17th-18th and throughout much of the following week when increasing natural and/or human triggered avalanche activity was expected. Due to this strong upper trough and the following sustained warming trend of the week leading to Memorial Day, the NWAC issued several special avalanche statements warning not only of the increased potential for difficult and dangerous climbing conditions from the 16th-18th, but for increasing natural loose, wet loose or isolated wet slabs slides the following week. With a prolonged warming and some increase in high clouds late in the week, the stage was set for a significant spring slide cycle, with some slides possibly releasing to the ground as the entire snowpack gradually became weak and isothermal at mid elevations. While field reports were still being received at the time of this writing, it is expected that significant slides will occur, at least in some areas.

The trend in NWAC avalanche warnings issued by month and annually is shown below. As is evident in the charts and from the seasonal discussion above, fewer than normal warnings or special statements were issued during the 2002/03 season—due primarily to a slow start to the season and fewer than normal storms during the period of December-February. Although an unusually cool and wet April maintained moderate to considerable danger at times, the lack of any appreciable warming resulted in a lack of avalanche warnings; however as indicated above, a series of special avalanche statements were issued in May when late season storms were followed by substantial warming.

Figure 2. Monthly totals of days with warnings or special statements

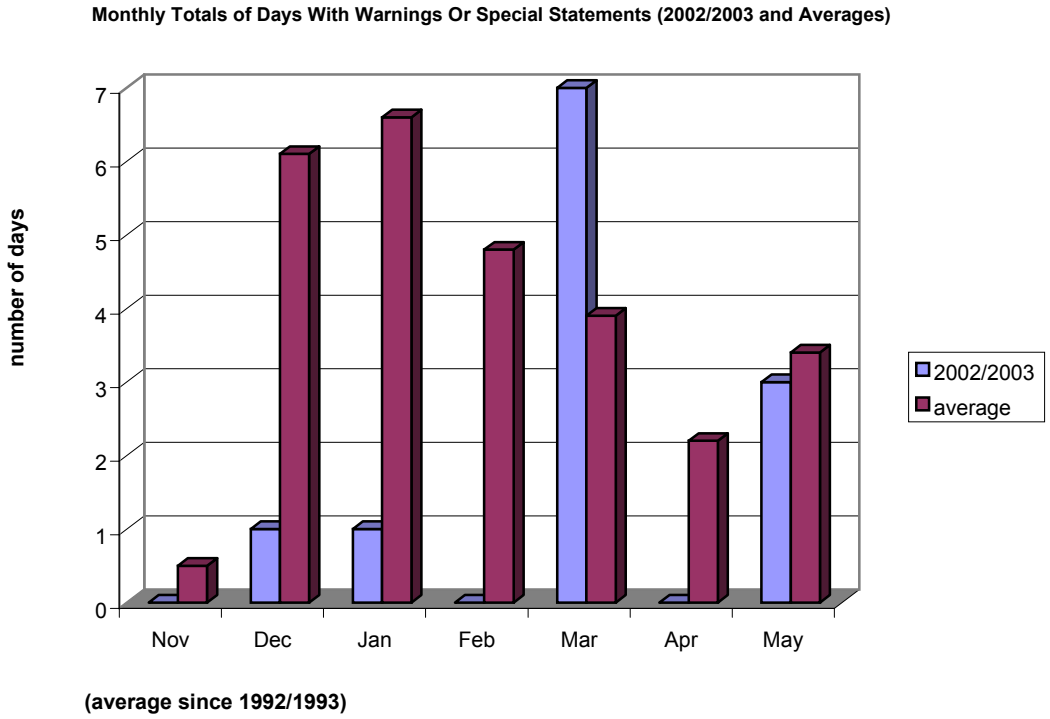
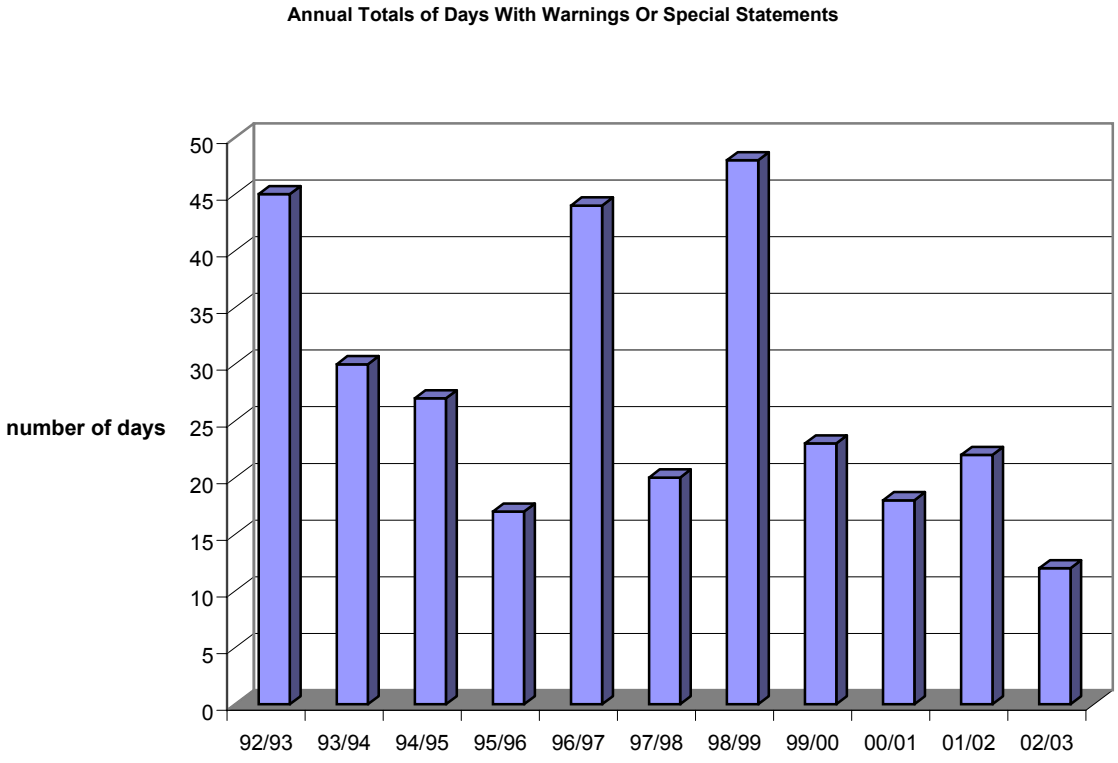


Figure 3. Annual totals of days with warnings or special statements



AVALANCHE ACCIDENTS

After a record setting winter of 35 avalanche fatalities nationwide in 2001/02, avalanche accidents picked up again in late November and December of 2002, reaching 8 fatalities by early January. The fatal late December accident near Crystal Mountain, WA helped keep the Northwest avalanche fatality average (Washington and Oregon) around 1.5 deaths/year (as seen from the state fatality chart below). Overall snowmobilers continued to account for a relatively high percentage of the fatal avalanche accidents during the early part of the year and this continued through the remainder of the year. The charts below show the annual fatality total (and 5-yr moving average) since 1950 and the state by state totals since 1985/86.

As weather returned to many western US locations in late January and early February, a rash of accidents ensued, with the US avalanche fatality total increasing to 15 and the Canadian total jumping to 16 by mid-March (two separate accidents claimed 14 lives). Further moderate to heavy snowfall and strong winds moved into the southwest US mid-late February and across the northern mountains in later February. This produced increasingly dense snow overlying faceted or lower density snow that had developed during clearing or weak storm and several more avalanche accidents produced four more US fatalities (a snowboarder, a climber, a back country skier, and snowmobiler), with the US fatality total reaching 19 by the 25th of February. In the Northwest, four snowshoers out for the day on Mt St Helens on February 16th were very fortunate to not become included in the statistics. The incident is briefly described in an email forwarded to the Avalanche Center:

> *To Whom it May Concern:*
>
> *I would like to report the following incident.*
>
> *On Sunday February 16th a party of 4 snowshoers were traveling along the summer climbing route on Mt. St Helens when at approximately noon they were caught in an avalanche. The climbers were at approx. 6600 feet. The party of 4 had just passed a party of three other climbers. After the avalanche one of member of the party of 4, myself, was able to get out of the snow on their own. I then signaled the other party who was in sight that we were in need of assistance. I then looked for the climber closest to me before the slide. I located him since his foot was above the snow and began to unbury him. During this time the party of 3 that was assisting us was able to locate the 2 other members of my party and begin to unbury them. The party of 3 estimated we traveled approx 30 yards from the avalanche. Neither the party of 4 nor the party of 3 carried beacons. The longest anyone remained beneath the snow is estimated at 4-5 minutes. Following this incident both parties descended to the trailhead at climber's bivouac. The incident has not been reported until now.*
>
> *If you have any questions or would like more info please contact me.*

Forecast staff at the Avalanche Center have tried and will continue to try to get more detailed information about the incident.

Several accidents occurred during the storm cycle from the 6th through the 9th of March. Here are some briefs...

On Friday the 7th at Mt Hood Meadows three snowboarders broke and in-area closure near "God's Wall" that empties into central Heather Canyon. Jumping into the steep and gullied "Backyards" run, one of the boarders triggered a soft slab that caught and carried him into a creek. He was completely buried for 20 minutes under four feet of avalanche debris before his friends who noticed his absence, climbed back upslope and located him by beacon. Fortunately he was uncovered unharmed by the other party members. A very close call to say the least! (More details on this incident are on the NWAC web site under Accidents)

Another close call on the 7th near Stevens Pass a skier triggered a slide that released above him and caught him carrying him through trees and over a cliff band, fortunately he sustained only minor injuries.

On the 8th, more close calls...an avalanche professional triggered a slide that released above him and carried him about 75 yards before he was able to stop prior to being carried into trees. No injuries were sustained, however a ski and a set of poles remained buried on the slope as a memento.

Also on the 8th at Skyline Ridge across from Stevens Pass ski area, two boarders triggered a 4-foot slab that released about 3 to 400 feet winds and ran 2000 feet vertical to the old highway. Again, fortunately they were not caught by this

rather large slide.

On the 23rd of March at approximately 1330 hours we had a snowmobiler caught and buried by an avalanche in the Longs pass area of Kittitas County. The subject was rescued by riding companions after they saw an arm sticking out of the snow.

On March 27th a skier at Crystal Mountain in a run called Brand X triggered a 1-foot deep by 8-foot wide avalanche, which propagated to 30 wide. The victim was carried into and pinned against trees. Though only partially buried, snow pressure between the slide debris and the tree made breathing very difficult and the victim was losing consciousness as he was being dug out.

On March 29th a lone skier high on the south side of Granite Mountain either triggered or was caught in a natural wet snow avalanche and carried down the mountain side to where the wide starting zone narrows to 30 feet. The victim suffered some serious injuries including a punctured lung and multiple broken bones, and after being rescued from the path and debris, was evacuated by helicopter to Harborview Medical Center in Seattle in serious condition.

With the El Nino year producing unusual snowpack (strong and weak) layers and unusual loading patterns and unusual accidents, both the US and North American avalanche fatality total continued to climb upward in February and March, reaching a new modern day record of 52 in North America by late March (26 fatalities in the US and 26 in Canada). The following figures show the overall high and continued upward trend in US avalanche accidents during the past 10 years as well as this comparison with annual Northwest avalanche fatalities, which fortunately have remained relatively flat during the same period.

Winter-like weather continued to intermittently plague many regions of the country through the end of April and into early May as the winter summary above indicates. This helped maintain new areas of unstable snow throughout the mountain west, and contributed to several late season avalanche fatalities involving climbers and skiers in Alaska, and snowmobilers in both California and Alberta, Canada. These accidents further increased the already record setting avalanche fatality year for North America (58 as of 5/14/03) and brought the US total to near its 5-year moving average of around 30 deaths/year. Further accident updates for this unusual year will be available through June at the NWAC web site (accidents.nwac.us) (or on www.avalanche.org).

Figure 4. US Avalanche Fatalities by year, 1950-2003 (with 5-yr moving average)

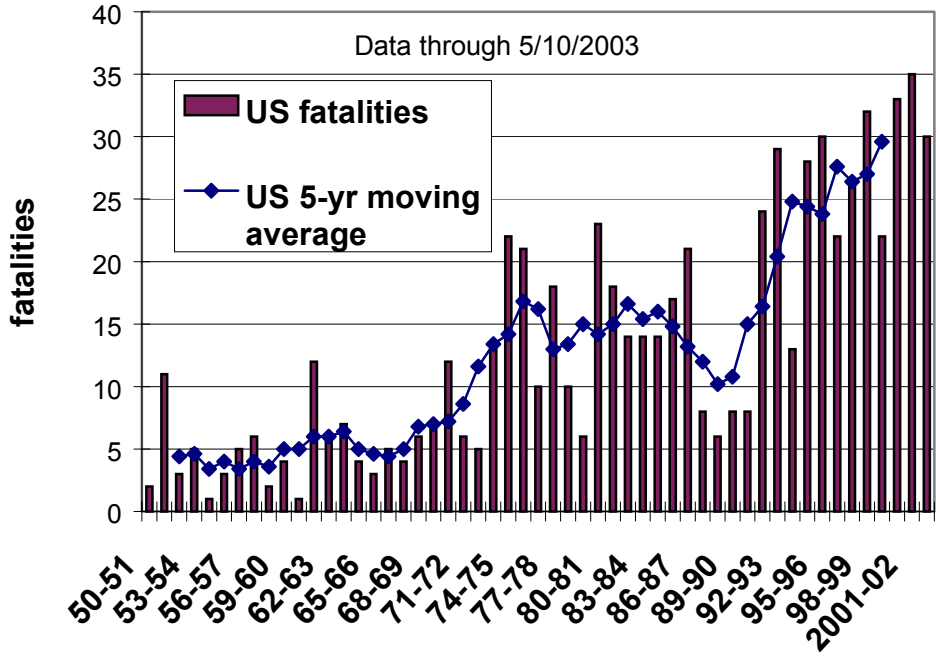


Figure 5. US versus NW Annual Avalanche Fatalities--1976-2003

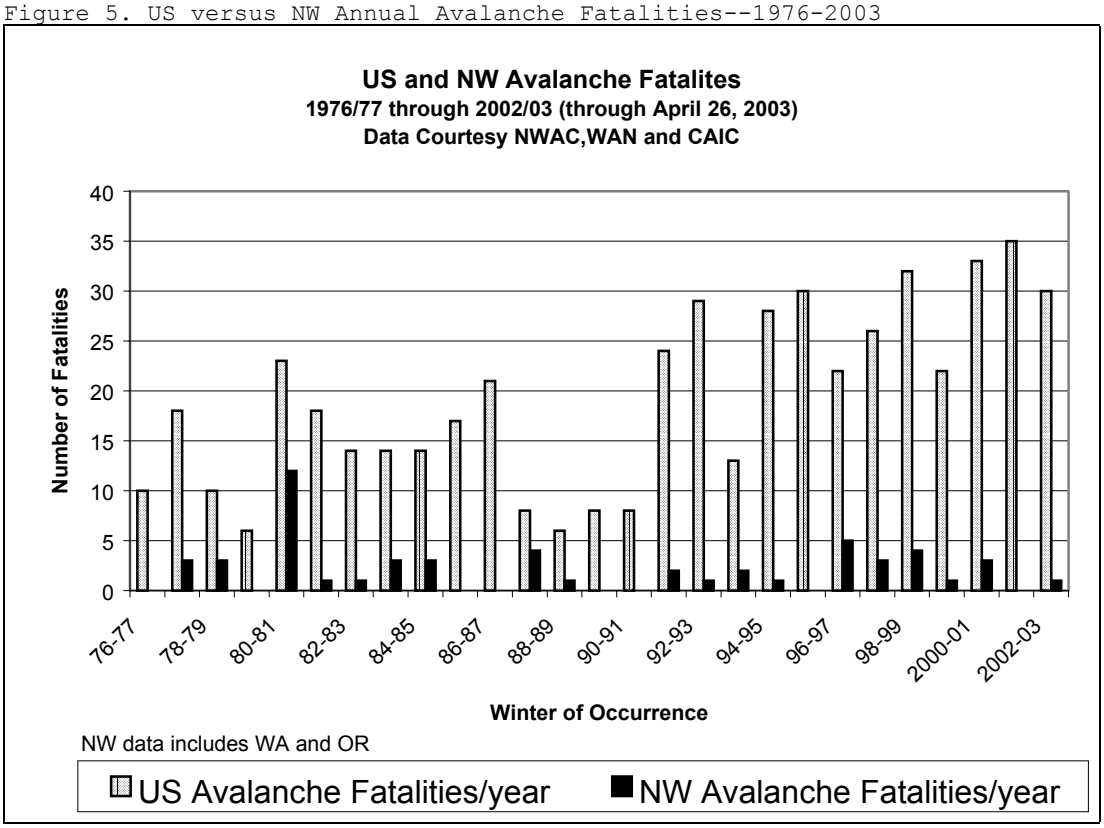


Figure 6. US Avalanche Fatalities by State, 1985-2003 (data through 1/6/2003)

UNITED STATES AVALANCHE FATALITIES by STATE
1985-1986 to 2002/03 (to May 10, 2003)

	Winter Season																		18 Years		
State	85/86	86/87	87/88	88/89	89/90	90/91	91/92	92/93	93/94	94/95	95/96	96/97	97/98	98/99	99/00	00/01	01/02	02/03	Total	Avg	State
CO	4	11	5	4	4	6	9	12	1	9	7	1	6	6	8	4	6	6	109	6.1	CO
AK	0	6	2	0	1	1	2	7	2	6	8	4	3	12	5	4	11	4	78	4.3	AK
UT	5	2	0	0	1	0	5	3	1	5	2	6	2	5	2	6	5	1	51	2.8	UT
MT	2	1	0	0	1	0	1	1	6	3	3	1	7	2	2	7	9	4	50	2.8	MT
WY	2	0	0	0	0	0	2	1	1	1	3	2	1	2	0	7	2	7	31	1.7	WY
WA	2	0	1	0	0	0	2	0	0	1	0	5	2	3	1	3	0	1	21	1.2	WA
ID	0	1	0	0	0	0	0	2	0	0	3	3	3	0	2	0	1	3	18	1.0	ID
CA	2	0	0	0	1	0	2	1	0	2	0	0	1	1	0	2	1	1	14	0.8	CA
NH	0	0	0	0	0	1	0	0	0	0	3	0	0	0	1	0	0	2	7	0.4	NH
OR	0	0	0	1	0	0	0	1	2	0	0	0	1	1	0	0	0	0	6	0.3	OR
NV	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	1	3	0.2	NV
NY	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	0	0	2	0.1	NY
AZ	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1	0.1	AZ
NM	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0.1	NM
TOTAL	17	21	8	6	8	8	24	29	13	28	30	22	26	32	22	33	35	30	392	21.8	TOTAL

And the fatalities by category thus far for the current winter season are shown below, along with the percentage of fatalities by category since 1997.

Figure 7. 2002/03 Avalanche Fatalities by Category

2002/03 US Avalanche Fatalities by Activity Category
30 total thru 5/10/03--Data courtesy NWAC, CAIC and WAN

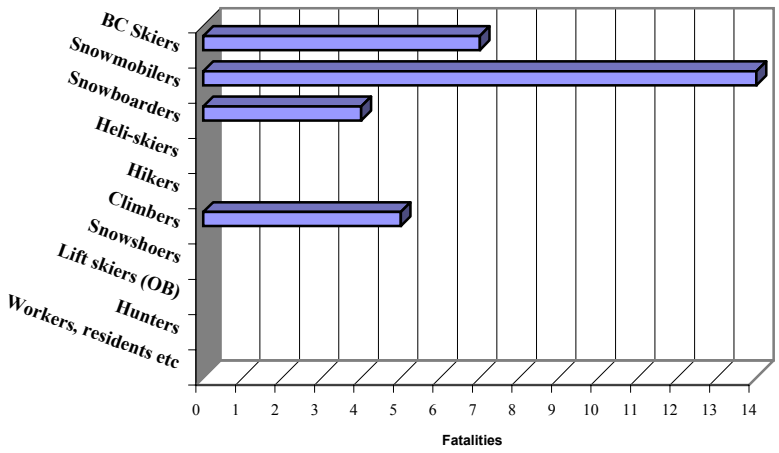
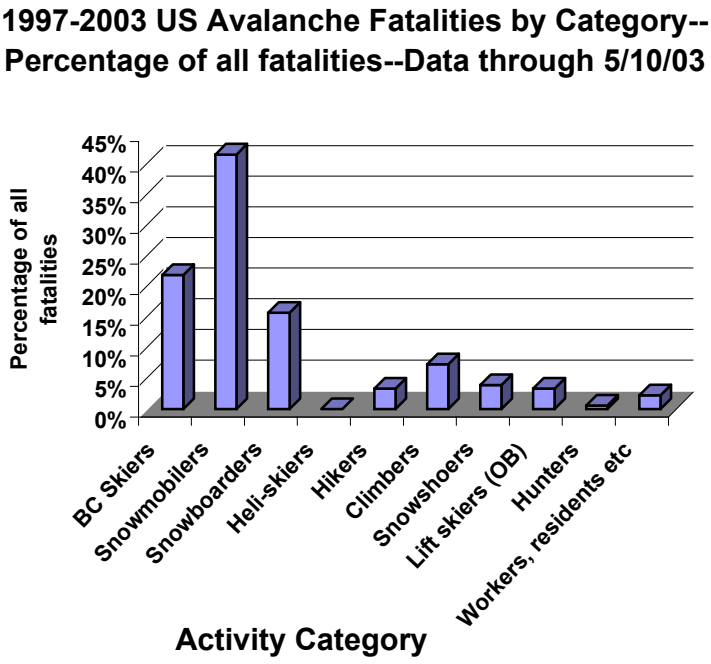


Figure 8. Avalanche Fatalities by Category--1997-2003



FORECASTING OPERATIONS

With large storms finally breaking through the dominant and previously blocking ridge in mid-December, the forecast season began in earnest with special statement issued on the 12th and 13th of December, with normal daily operation starting on the 14th—easily the latest opening of the NWAC since its inception in 1976. However, the late opening did allow for a lot of instrumentation work and office programming prior to the daily forecast grind—and this hopefully allowed for more reliable forecast dissemination and higher quality data from most of the instrumentation network.

Once the season was underway, the NWAC issued twice daily mountain weather forecasts (for all but a few days when stationary and strong upper ridging dominated NW weather, produced little or no changes in either weather or snow stability, and obviated the need for an afternoon forecast update) and daily or more often avalanche forecasts through mid-April, finally closing daily operation on Sunday, April 21st. However, due to unusually cool and intermittently snowy weather for the remainder of April through early-mid May, and the need for daily mountain weather forecasts (4+ days/week) for WSDOT re-opening of Chinook Pass, NWAC continued to monitor weather and snowpack conditions on a regular basis during the week through the fourth week of May. Although Chinook Pass opened on May 15th, new snow arriving during the previous week necessitated WSDOT avalanche crew presence at the pass through the following week (into Memorial Day weekend) so as to limit avalanche problems and maximize motorist safety on the highways.

2002/03 CLIMATE

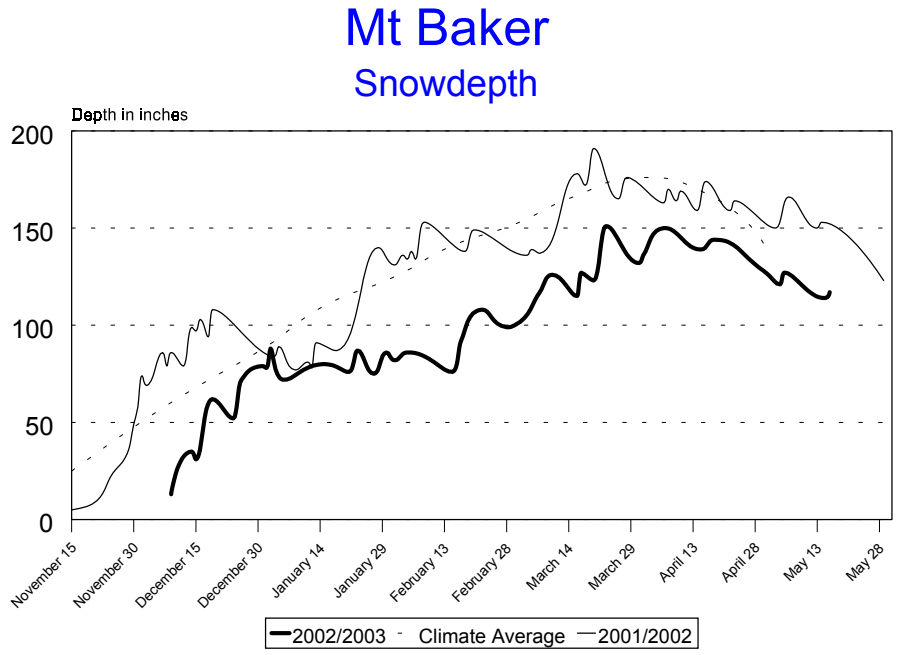
Early season expectations for the winter season in the northwest were tempered by predictions from the National Centers for Environmental Prediction (NCEP). The early season forecast anticipated a slightly drier and warmer than average winter—which certainly seemed to be the case through February. This prediction was mainly based upon the ongoing moderate El Nino that had been developing in the tropical Pacific since the spring of 2002.

And develop it did...for example, Snoqualmie Pass recorded its first measurable snow on

December 5, 2002 when they received a whooping 2 inches! The following climatological snow depth graphs and charts indicate how dry and warm the season started, its progression of dry and warmer conditions through February, and the considerable rebound of winter in March-early May. The observed monthly freezing level charts shown in the seasonal summary also dramatically indicate this weather trend.

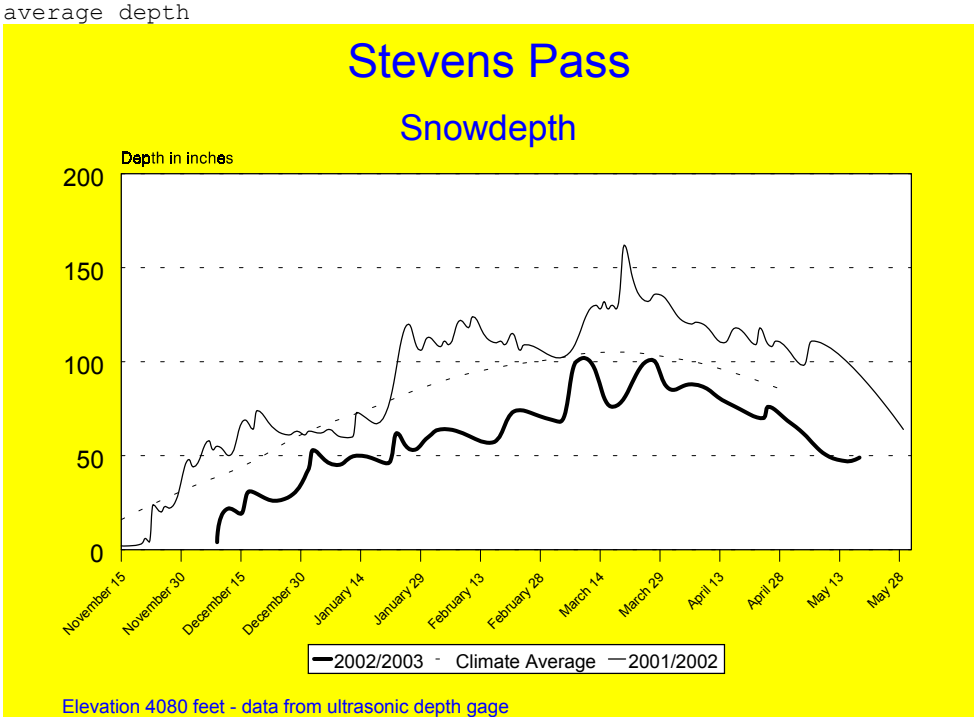
Climatological Snow Depth Graphs

Figure 9. Snowdepth data from Mt Baker, WA for 2002/03 versus climatological average depth



Elevation 4220 feet - data from ultrasonic depth gage

Figure 10. Snowdepth data from Stevens Pass, WA for 2002/03 versus climatological average depth



Elevation 4080 feet - data from ultrasonic depth gage

Figure 11. Snowdepth data from Snoqualmie Pass, WA for 2002/03 versus climatological average depth

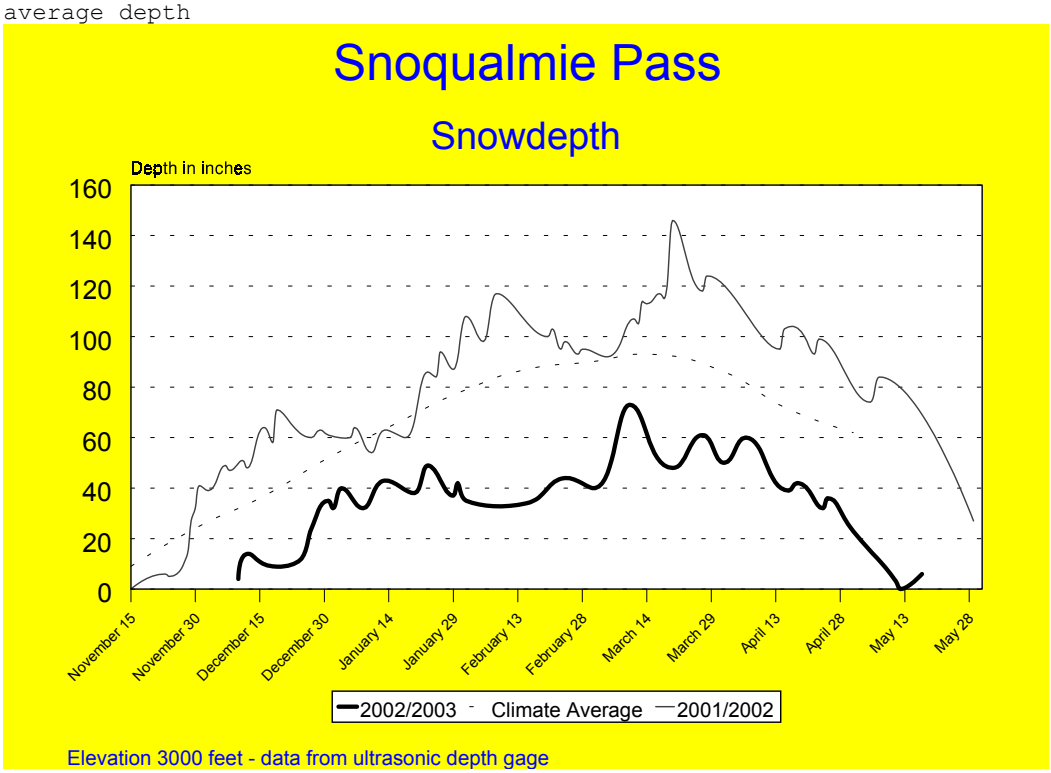


Figure 12. Snowdepth data from Paradise, WA for 2002/03 versus climatological average depth

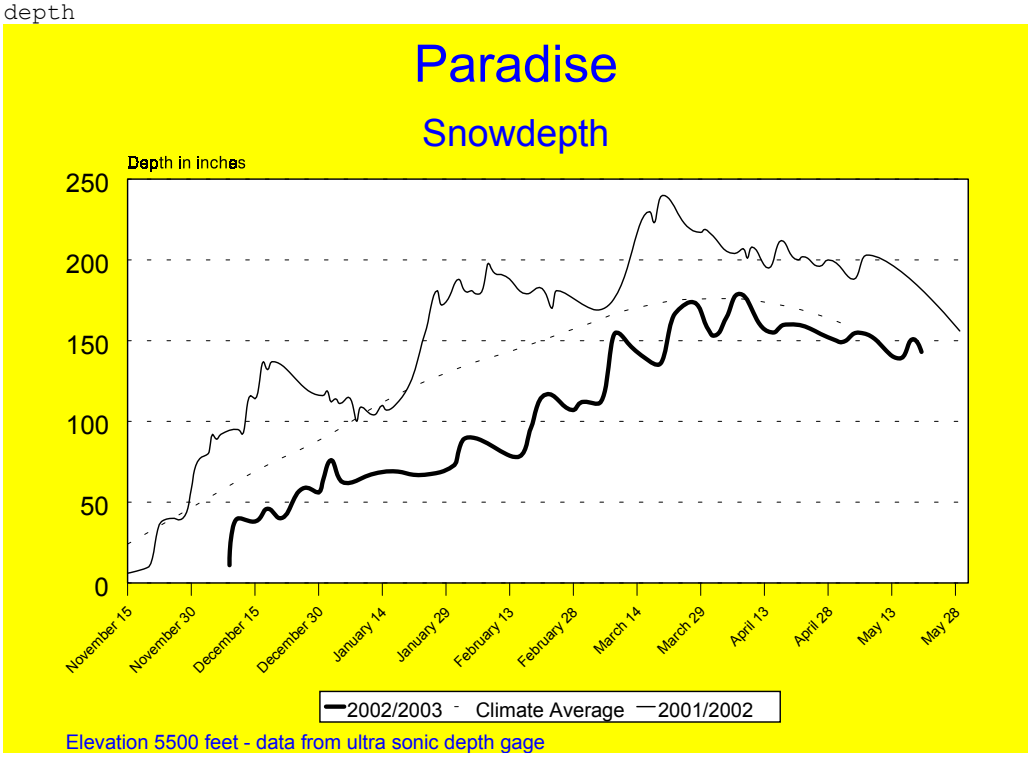
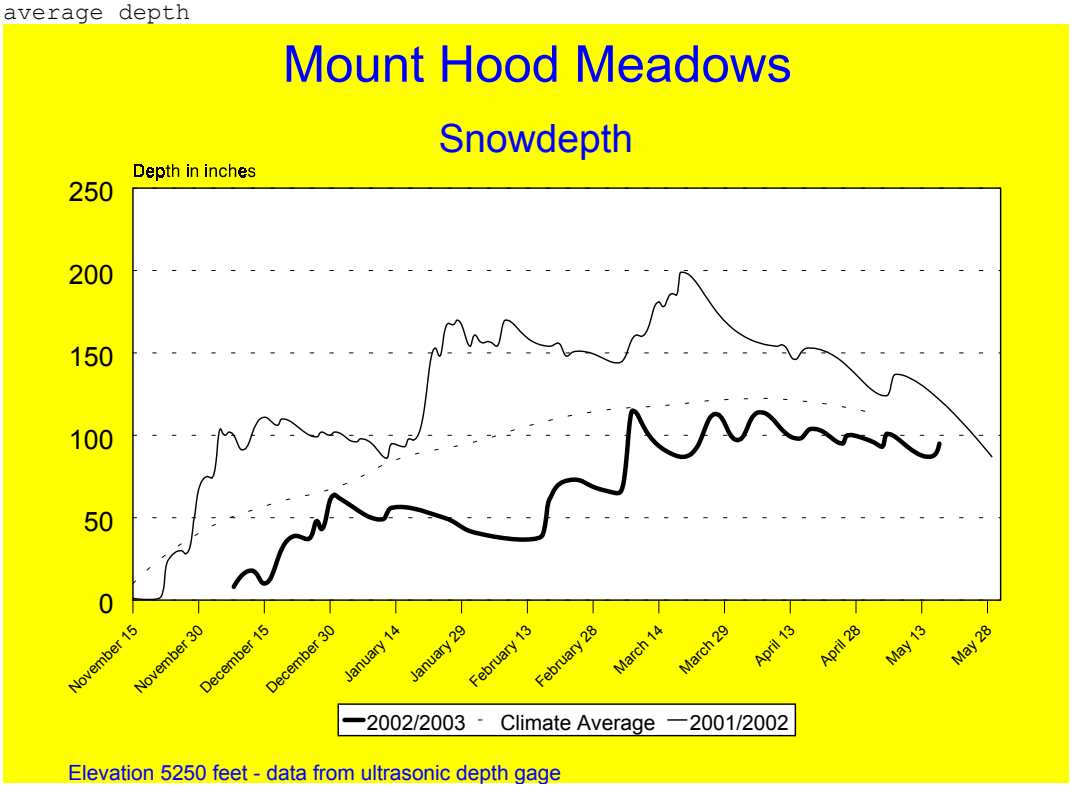


Figure 13. Snowdepth data from Mt Hood Meadows, OR for 2002/03 versus climatological average depth



The lower than normal snow depths shown in the climatological graphs above are also supported by cumulative snowfall (for Snoqualmie Pass) and seasonal precipitation information (for Stevens Pass—snow and rain). The annual snowfall data for Snoqualmie Pass alludes to a generally drier and warmer than normal winter. And monthly and annual precipitation figures for Stevens Pass, WA (see Figures below) both indicate below normal precipitation for the year and for most months, with notable exceptions in January (where most precipitation was received as rain—described in the weather and avalanche summary above) and April, when an unusually cool and wet spring descended on the area.

Figure 14. Cumulative snowfall for Snoqualmie Pass (Alpental) by year—1949/50 to 2002/03 (data through 5/22/03)

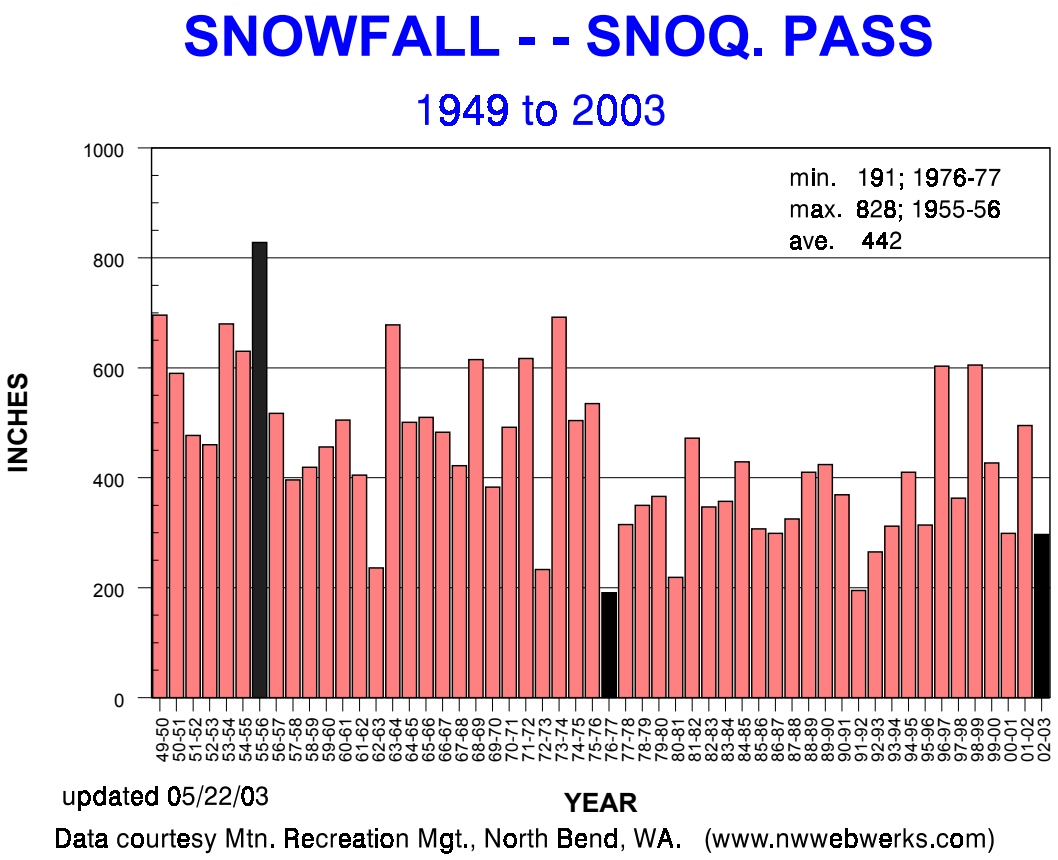


Figure 15. Seasonal precipitation for Stevens Pass, WA—Oct-May, 1973-2003

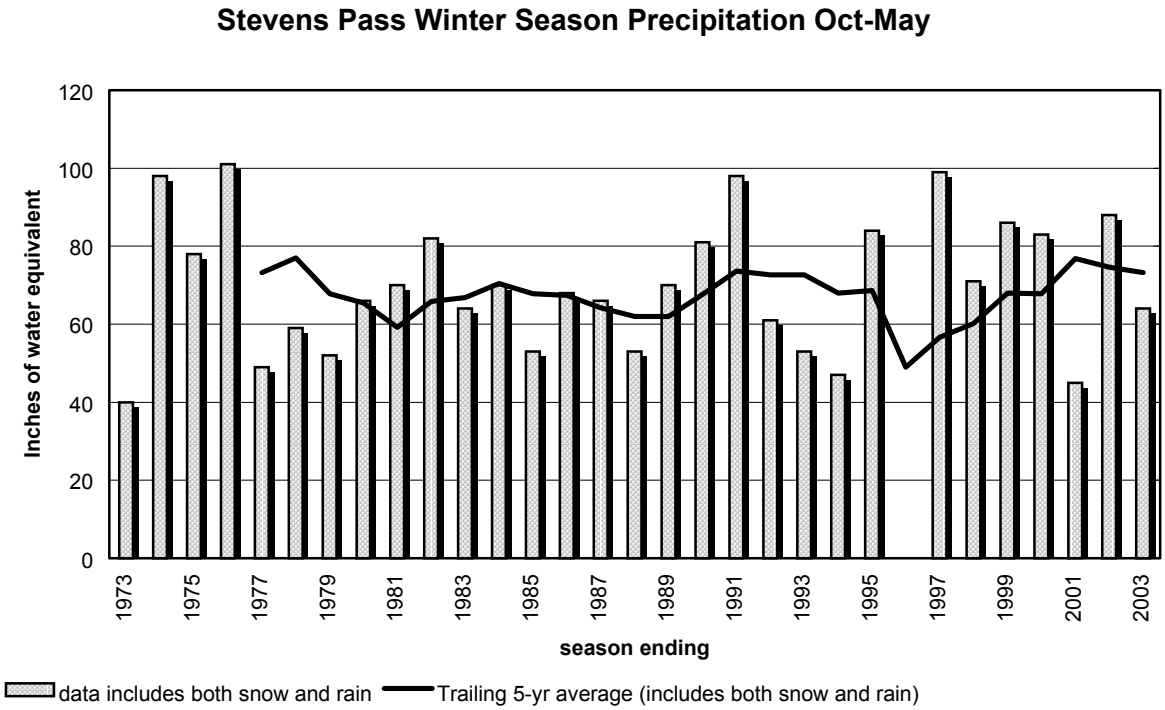
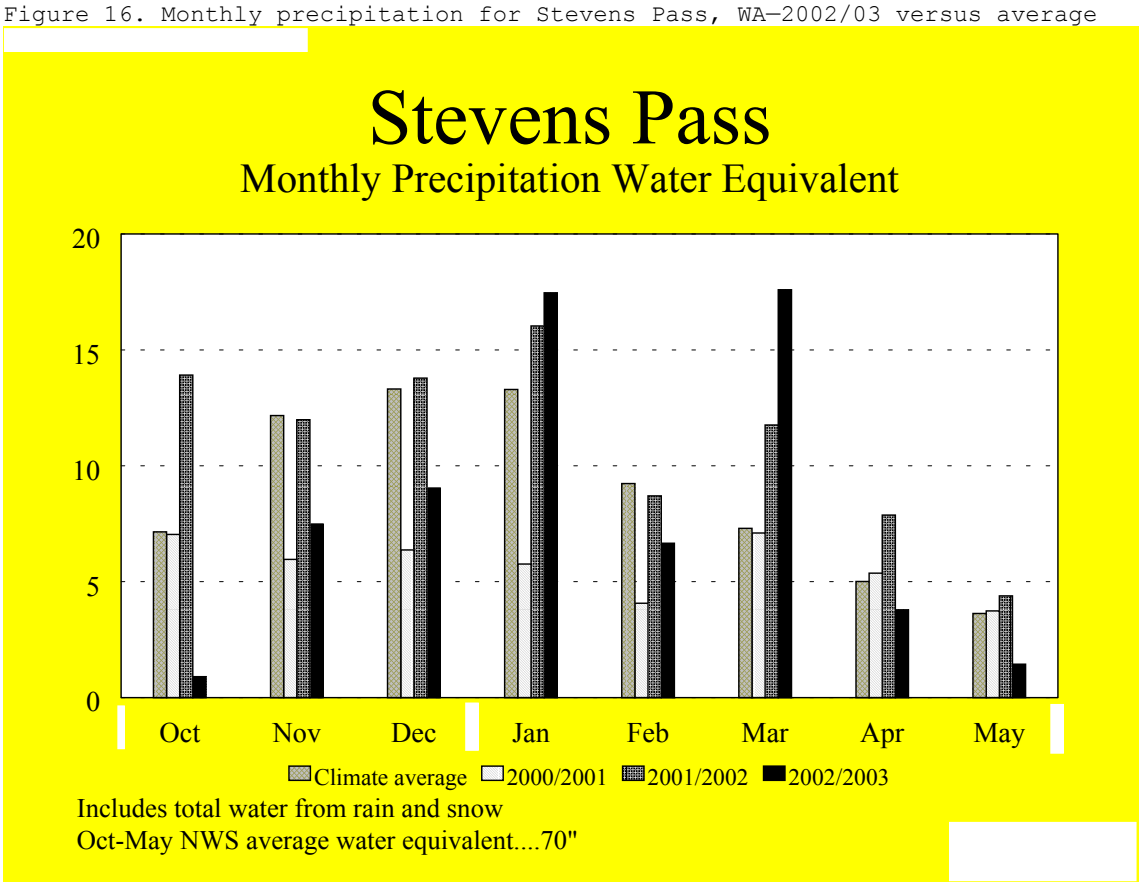


Figure 16. Monthly precipitation for Stevens Pass, WA—2002/03 versus average



Climatological Snow Depth Tables

The semi-monthly climatological snowdpepth tables below depict not only the trends shown visually above but how the snow depth measurements this past year compare with the maximums and minimums at each site over the past 30-50 years (length of record depending on the station). This time of record is shown in the summaries after mid-March, but is included here for reference:

RECORDS BEGIN:

HURRICANE 1979, MT BAKER 1926, STEVENS 1939,
SNOQUALMIE 1929, MISSION RIDGE 1970, CRYSTAL 1967, PARADISE 1926,
WHITE PASS 1976, TIMBERLINE 1973, MT HOOD MEADOWS 1974.

December

December 1, 2002

CLIMATOLOGICAL SNOWDEPTH INFORMATION
NORTHWEST WEATHER AND AVALANCHE CENTER
ISSUED THROUGH NATIONAL WEATHER SERVICE SEATTLE

FOR : DAY 1 MONTH 12 YEAR 2002

DATA IN INCHES, -99 DENOTES MISSING DATA

	CURRENT DEPTH	CLIMATE AVERAGE	PER CENT OF NORMAL	LAST YEAR	THRU 2001 MAX/YEAR	THRU 2001 MIN/YEAR
MT BAKER	10	49	20	58	140/1948	1/1939
STEVENS	0	32	0	37	67/1942	0/1941
SNOQUALMIE	0	25	0	44	84/1955	1/1969
STAMPEDE	0	31	0	41	93/1945	0/1976
PARADISE	8	48	17	68	125/1994	1/1976
WHITE PASS	0	20	0	30	53/1984	1/1999
MT HOOD	8	43	19	60	113/1984	10/1995

December 15, 2002

	CURRENT DEPTH	CLIMATE AVERAGE	PER CENT OF NORMAL	LAST YEAR	THRU 2001 MAX/YEAR	THRU 2001 MIN/YEAR
MT BAKER	31	68	46	104	168/1948	16/1976
STEVENS	19	44	43	66	80/1973	5/1976
SNOQUALMIE	12	36	33	61	116/1948	0/1976
STAMPEDE	-99	44	-99	-99	119/1948	9/1976
PARADISE	36	69	52	114	170/1948	4/1976
WHITE PASS	12	31	39	42	73/1996	2/1989
MT HOOD	10	59	17	110	118/1984	8/1989

As described in the weather and snow pack section above, the Northwest winter finally arrived in a briefly more earnest fashion in mid-late December, and the snowdepths measured on the 1st of 2003 showed this. While not reaching the norm in all areas, most sites at least responded with a rather healthy rebound toward a more normal snow pack.

January

January 1, 2003

	CURRENT DEPTH	CLIMATE AVERAGE	PER CENT OF NORMAL	LAST YEAR	THRU 2002 MAX/YEAR	THRU 2002 MIN/YEAR
MT BAKER	84	88	95	98	190/1949	1/1928
STEVENS	43	62	69	63	117/1956	10/1981
SNOQUALMIE	35	53	66	64	136/1949	0/1981
STAMPEDE	39	59	66	62	132/1949	0/1981
PARADISE	72	91	79	114	163/1969	20/1977
WHITE PASS	35	35	100	40	84/1997	4/1990
MT HOOD	62	70	89	101	145/1985	6/1981

Heavy rainfall and high freezing levels in early January brought significant settlement of the recently revived snow pack and coming at a time of normally strong average snow depth increases the climatological depth totals plummeted in early-mid January.

January 15, 2003

	CURRENT DEPTH	CLIMATE AVERAGE	PER CENT OF NORMAL	LAST YEAR	THRU 2002 MAX/YEAR	THRU 2002 MIN/YEAR
MT BAKER	80	108	74	88	180/1971	15/1981
STEVENS	45	73	62	70	146/1969	6/1981
SNOQUALMIE	43	65	66	62	123/1969	0/1981
STAMPEDE	45	73	62	54	179/1972	0/1981
PARADISE	66	112	59	107	216/1969	31/1981
WHITE PASS	30	45	67	37	80/2000	0/1981
MT HOOD	54	86	63	94	144/1989	0/1981

As is evident from the climatological snowdepth figures below, a rather dry and intermittently warm and rainy weather pattern in January and much of February kept

snowdepths averaging about 50-70% of normal for much of the time.

February

February 1, 2003

	CURRENT DEPTH	CLIMATE AVERAGE	PER CENT OF NORMAL	LAST YEAR	THRU 2002 MAX/YEAR	THRU 2002 MIN/YEAR
MT BAKER	82	124	66	131	234/1933	17/1981
STEVENS	58	87	67	113	152/1964	10/1981
SNOQUALMIE	41	80	51	108	154/1964	8/1977
STAMPEDE	46	88	52	118	228/1946	2/1977
PARADISE	78	133	59	188	240/1969	27/1977
WHITE PASS	26	53	49	86	88/1997	0/1977
MT HOOD	41	99	41	161	161/2002	15/1981

February 15, 2003

	CURRENT DEPTH	CLIMATE AVERAGE	PER CENT OF NORMAL	LAST YEAR	THRU 2002 MAX/YEAR	THRU 2002 MIN/YEAR
MT BAKER	82	140	59	154	244/1999	24/1977
STEVENS	58	96	60	116	166/1956	16/1977
SNOQUALMIE	37	88	42	106	168/1949	4/1977
STAMPEDE	-99	93	-99	118	202/1949	0/1977
PARADISE	72	145	50	184	264/1972	24/1977
WHITE PASS	24	56	43	78	100/1999	0/1977
MT HOOD	41	109	38	157	162/1999	27/1981

March

March 1, 2003

	CURRENT DEPTH	CLIMATE AVERAGE	PER CENT OF NORMAL	LAST YEAR	THRU 2002 MAX/YEAR	THRU 2002 MIN/YEAR
MT BAKER	115	151	76	153	296/1999	48/1981
STEVENS	67	100	67	105	196/1956	30/1981
SNOQUALMIE	44	90	49	94	198/1956	20/1981
STAMPEDE	60	101	59	106	195/1969	21/1981
PARADISE	109	159	69	177	276/1999	67/1977
WHITE PASS	36	57	63	60	115/1999	11/1977
MT HOOD	67	116	58	147	199/1999	38/1981

However, with the arrival of March so also arrived the long awaited westerly flow (see the winter narrative above). Interpolated snowdepth averages were computed on the 9th of March with current depths for all stations rising substantially and averaging 95% of climate average. Many stations nearly doubled their snow depths as a result of the storm cycle in early March, and the percentages on the 15th of March still reflect this remarkable recovery from the early season drought. Note the new stations added in during March—this change in format was made possible by some fine programming and data entry by Garth and several volunteers/students. Also note that for these stations the period of data differ from station to station, depending on the type and longevity of the particular site:

New Climatological Summary Form Information

RECORDS BEGIN: HURRICANE 1979, MT BAKER 1926, STEVENS 1939, SNOQUALMIE 1929, MISSION RIDGE 1970, CRYSTAL 1967, PARADISE 1926, WHITE PASS 1976, TIMBERLINE 1973, MT HOOD MEADOWS 1974.

March 15, 2003

	CURRENT DEPTH	CLIMATE AVERAGE	PER CENT OF NORMAL	LAST YEAR	THRU 2002 MAX/YEAR	THRU 2002 MIN/YEAR
HURRICANE	88	108	81	147	252/1999	32/1981
MT BAKER	136	165	82	191	305/1999	44/1981
STEVENS	80	104	77	135	200/1956	26/1981
SNOQUALMIE	54	93	58	114	195/1956	10/1957
STAMPEDE	71	104	68	-99	216/1964	13/1981
MISSION	54	46	117	54	83/1999	20/1976
CRYSTAL	72	67	107	104	136/1999	9/1981
PARADISE	133	171	78	224	357/1956	72/1981
WHITE PASS	43	57	75	86	132/1997	8/1981
TIMBERLINE	151	148	102	248	258/1999	34/1981
MEADOWS	93	127	73	178	288/1974	33/1981

April

April 1, 2003

	CURRENT DEPTH	CLIMATE AVERAGE	PER CENT OF NORMAL	LAST YEAR	THRU 2002 MAX/YEAR	THRU 2002 MIN/YEAR
HURRICANE	94	107	88	133	252/1999	48/1981
MT BAKER	171	175	98	186	311/1999	72/1934
STEVENS	84	102	82	132	192/1956	24/1941
SNOQUALMIE	50	86	58	112	170/1956	2/1992
STAMPEDE	72	102	71	134	183/1956	17/1992
MISSION	49	47	104	54	86/1983	20/1973
CRYSTAL	76	69	110	96	144/1999	16/1981
PARADISE	151	175	86	220	327/1956	66/1941
WHITE PASS	42	54	78	76	110/1997	0/1992
TIMBERLINE	168	163	103	253	300/1999	57/1981
MEADOWS	100	124	81	167	199/1999	55/1992

Despite the National Weather Service 30 and 90 day outlooks for temperature and precipitation indicating above normal values in the Northwest for both categories for the period April-June, unusually cool and normally wet weather continued for most of the region through April and into May. As the snow pack figures suggest, this time of the year continued to be a time of very limited melt and most depths remained constant or slightly increased with Chinook Pass recording its maximum seasonal snowdepth of 188 inches on the 6th of April and Paradise of 179 inches on the 7th of April. Other seasonal snowdepth maxes recorded in April included Mt Hood Meadows (113 inches on 4/6/03)and Timberline Lodge (184 inches—automated and 195--manual on the 7th). However, some stations did not record maxes until early May, such as Crater Lake (117 on May 5th).

April 15, 2003

	CURRENT DEPTH	CLIMATE AVERAGE	PER CENT OF NORMAL	LAST YEAR	THRU 2002 MAX/YEAR	THRU 2002 MIN/YEAR
HURRICANE	95	115	83	123	252/1999	65/2001
MT BAKER	148	168	88	168	290/1999	56/1934
STEVENS	78	95	82	117	170/1956	17/1941
SNOQUALMIE	42	73	58	100	153/1974	0/1992
STAMPEDE	-99	100	-99	-99	216/1964	9/1992
MISSION	45	49	92	45	79/1983	21/1990
CRYSTAL	70	71	99	82	130/1999	30/1981
PARADISE	155	173	90	200	302/1972	68/1934
WHITE PASS	30	45	67	55	95/1997	0/1992
TIMBERLINE	175	161	109	220	300/1999	71/1977
MEADOWS	99	122	81	146	190/1982	54/1992

May

May 1, 2003

DATA IN INCHES, -99 DENOTES MISSING DATA

	CURRENT DEPTH	CLIMATE AVERAGE	PER CENT OF NORMAL	LAST YEAR	THRU 2002 MAX/YEAR	THRU 2002 MIN/YEAR
HURRICANE	88	96	92	104	145/1982	67/1988
MT BAKER	138	138	100	153	270/1999	20/1934
STEVENS	67	83	81	102	141/1964	36/1942
SNOQUALMIE	24	62	39	79	131/1974	0/1992
STAMPEDE	50	82	61	-99	176/1964	1/1992
MISSION	35	37	95	46	56/1999	15/1972
CRYSTAL	59	76	78	74	115/1999	37/1996
PARADISE	146	161	91	191	295/1972	36/1941
WHITE PASS	-99	25	-99	30	70/1999	0/1996
TIMBERLINE	174	151	115	211	270/1999	43/1977
MEADOWS	97	115	84	131	162/1997	70/1994

Water data from the Natural Resources Conservation Service suggests much the same trend as shown by the late season snowdepth figures given above. The following is excerpted from the NRCS report shown below.

NRCS Washington Water Supply Outlook Report

(as of May 1, 2003)

General Summary— *Near normal temperatures combined with near to above normal precipitation throughout the month of April helped sustain mountain snowpack. Some areas even recorded slight increases in snowpack. Some of these increased were due to cold snowy storms where others were rain-on-snow events that initially helped boost snow water content. All added water to the snowpack is beneficial, as long as it stays in place until it's needed. Unfortunately we did experience some early runoff, seeing some stations melting out weeks earlier than normal. Salmon Meadows SNOTEL, near Conconully, started the year with above normal snow, then peaked two weeks early in mid March and melted out 20 days early. According to the National Weather Service we can expect a reasonable probability of getting above average precipitation with above normal temperatures for the next month.*

Precipitation—*During the month of April, the National Weather Service and Natural Resources Conservation Service climate stations reported near to above average precipitation totals throughout most of Washington river basins. The highest percent of average in the state was at Winthrop 1WSW, WA, which reported 332% of average for a total of 2.56 inches. The average for this site is .77 inches for April. The wettest spot in the state was reported at June Lake SNOTEL with an April accumulation of 14.2 inches, nearly 2 inches above the 30-year average for the site. Averages for the water-year increased considerably in most basins. The Lower Snake and Walla river basins reported the highest water-year average at 101%, up slightly form last month. The Upper Yakima River Basin reported the lowest at 83% of average and remained the same as last month with only 76% of average April accumulations.*

RIVER BASIN	May PERCENT OF AVERAGE	WATER YEAR PERCENT OF AVERAGE
Spokane	94	91
Colville-Pend Oreille	93	96
Okanogan-Methow	163	100
Wenatchee-Chelan	104	90
Upper Yakima	76	83
Lower Yakima	126	97
Walla Walla	123	101
Lower Snake	111	101
Cowlitz-Lewis	108	93
White-Green-Puyallup	103	86
Central Puget Sound	80	85
North Puget Sound	90	87
Olympic Peninsula	130	95

FIELD OPERATIONS

Substantial efforts were made to upgrade and streamline both data sites in the field and their automated display on the web site. These efforts resulted in generally much more stable and reliable data access and display for almost all stations. Although some significant problems cropped up (most notably Chinook Pass and Mt St Helens—see the detailed discussion below), in most instances problems were quickly addressed and fixed either through programming changes, visits to the site, or increasing reliance on cooperators for assistance in replacing or checking out sites. Some of the maintenance and station fixes/upgrades for the 2002/03 winter are listed below, followed by an outline of future (summer and fall, 2003) plans for the remote weather data network.

Early-mid Season Equipment Problems

Mt Hood Meadows—substantially upgraded. The ski area installed new larger and safer towers over the summer both at the base and above the top of the Blue chair at 6600 ft. Garth and Kenny spent two days in late October outfitting and completely reworking these antiquated sites. A new self-contained Campbell enclosure equipped with a CR10X micro logger, modem and battery was installed and programmed for the base station. New air temperature and relative humidity sensors were installed at both stations as well as new heated Taylor wind speed and direction sensors at the upper station. The existing precipitation gage and snowdepth sensors were re-installed on the new tower. Old confusing junction boxes were dispensed of in favor of a more efficient installation, eliminating the need for extraneous line runs.

Unfortunately, as the season progressed, an old ski area telemetry cable that ran between the new wind site and the logger in Patrol HQ became corrupted, rendering wind data intermittently useless during the early-mid part of the season. Fortunately, the ski area electrician and patrol worked together during the big ridge in early January to resolve the problem and a reliable direction reading was established late on the 11th of January.

Washington Pass—Two trips were required this fall to reestablish reliable data from that station. The Handar micro logger needed replacement as well as the snowdepth sensor. Data once again began to flow by early November, however preliminary talks with WSDOT staff are underway regarding conversion of this site to a more reliable and standardized Campbell Scientific data logger and associated VHF or possibly spread spectrum radio link. This will necessitate installation of several radio repeater sites and may also lead to relocation of the wind sensors to a higher elevation site that will more accurately portray wind transport affecting nearby avalanche paths.

Mt St Helens—Phone line problems intermittently terminated NWAC's connection to the site. While intermittent service was restored in early December, a continuation of phone line problems associated with Qwest lines or substation-switching problems occurred through late December. Full service is likely to resume sometime in the late spring or summer of 2003 when new high-speed data and voice lines should be installed by the Forest Service. Also, as the infrastructure (towers and land lines) are already installed at the Johnson Ridge Visitor Center (personal communication with Duane Chatham, MSH maintenance manager), it is hoped that a secondary weather site (wind speed and direction, air temperature) will be developed in cooperation with the MSHNVM—hopefully becoming operational in 2004.

Stevens Pass—After experiencing an increasing amount of labor and energy to maintain the old cooperative (WSDOT/NWAC) Grace Lakes telemetry station during the last few years (the site was initially installed in the late 1970's and despite repair of both telemetry and power cables, the site has slowly degraded over time), NWAC staff were planning to decommission and remove the station next spring. However, over the summer the existing precipitation/snow depth part of the station was removed and then relocated by WSDOT avalanche technicians to a new and better site near the Old Faithful wind site. The new installation was complete with a new tower base, new power lines for much of the run from the ski area, new telemetry cables between the existing wind and new precipitation site, and conduited cables near the tower. WSDOT also purchased a new spread spectrum radio system that would hopefully allow easy and reliable access of the station from a base station installed at the WSDOT Schmidt Haus snow study plot near the pass. Since the new installation offered the possibility of reasonable and reliable remote weather data at only minor added expense and little extra effort, Mark worked with WSDOT avalanche personnel to wire and program the data logger and to test out the spread spectrum radio system used to access the data. Unfortunately, the radio system

failed to work and after some effort and tests by WSDOT radio technicians, it was discovered that the new radio system was flawed. This has since been returned to the manufacturer for replacements that will be tested later this season. In the interim, WSDOT supplied a cel-phone link that, while more expensive, has at least allowed relatively reliable access of precipitation, snow depth, temperature and wind data from this system. Although some problems with the system and wind speed measurements persisted into January, this loss of data (zero wind speed for a week or more) apparently was due to incorrect wiring of wind sensor cables, and the problem was discovered and resolved by WSDOT avalanche technicians during the winter.

Routine maintenance was performed on many sites during the fall including Alpental ski area and Chinook Pass. The most common problems at these and other sites included blown fuses or broken regulated power supplies. However, precipitation gages also needed exchange or replacement at Mt Baker, Hurricane Ridge and Stevens Pass (Skyline Ridge), with problems related to broken heating elements, corrosion of the small circuit board, and possibly leveling problems. Also, several snow depth sensors became inoperable during the later fall—replacement and repair seemed the only reasonable solutions, with six sensors needing repair by the factory. Other problems and solutions included RV battery replacement and some swapping out of air temperature and relative humidity sensors.

Several stations continued to operate relatively unaffected through the summer and continued to produce good data through late fall into early winter with only a minimum of maintenance required. These included White Pass, Timberline (with the minor exception noted below), Mt Hood Ski Bowl, Mission Ridge, Paradise (minor exception below) and Crystal Mountain.

Timberline Lodge—With significant work done at this site performed the previous two years, most of the sensors here worked very well through the first of the year. However, a broken wire in the 24-hour snow depth sensor resulted in some down time for this reading in early January 2003. Fortunately the Timberline lift maintenance supervisor discovered the broken wire but attempts to re-solder the wire were not successful. A quick mail exchange of sensors ensued and a replacement sensor allowed for resumption of automated 24-hour depth readings prior to moderate storms in early-mid January.

Hurricane Ridge—The precipitation gage at Hurricane Ridge began to look suspect during late November and early December snowfall, and was subsequently scheduled for replacement as soon as possible. As a result, Mark and Dave Erickson, one of the new met interns—journeyed over to the Olympics and replaced the gage in early January. [The old gage had experienced a severe meltdown of the internal power board, with all of the heating power connectors blackened and blistered. Fortunately, it appears that damage to the remainder of the gage is minimal.] During this trip wiring associated with the snow depth sensor was also repaired along with a quick analysis of local snow pack structure and stability. Although the depth sensor is located over a questionable drift area (unfortunately this is the only place at present that the gage could be located), at the time of the repair it seemed to be reporting a reasonable snow depth (within about 6 inches of the nearby more wind-sheltered manual plot). Hence it was programmed into the hourly display to see how well it performed over time—late winter analysis indicated that given the wind exposed sensor location (and intermittent drift under the sensor), the reported depth appeared reasonable in most instances. However, plans call for relocation and reinstallation of a new tower for snowdepth and precipitation in a more sheltered location approximately 50-75 yards to the west of the existing generator building and current site. It is hoped that this relocation may be possible by next winter if approval with the Park Service is obtained.

Paradise—The total depth sensor began to be erratic in late December, and even more so in early January. With a scheduled instrumentation meeting with Mt Rainier National Park already scheduled, the field trip to the site was coordinated with the meeting and the sensor replaced in early January. Subsequent data indicates the total depth is working much more reliably. And the meeting with the Park was very fruitful, as the Park may have some instrumentation money for installation of several new weather stations around and on Mt Rainier to support fire weather and visitor safety, including possible locations at Sunrise, Ohanapecosh, and Camp Muir. NWAC forecasters plan to work with the Park and the Weather Service to ensure proper site selection as well as appropriate planning, design and installation of the system(s) for the intended location(s).

Mid-late Season Equipment Problems

In order to maintain continuity and reliability with both instrumentation and the snow pack, forecasters continued to make periodic trips to the mountains for snow pack analysis and to address varying instrumentation problems throughout the winter. Some of the more significant problems addressed in the mid-late part of the winter are described

below.

Paradise—As a result of increasing problems with phone line access of the Paradise NPS weather station, Garth journeyed to the site on 1/30/03 and replaced the modem. This seemed to resolve the problem and subsequent connections have been regular and smooth!

Mark and forecaster intern Dave Erickson journeyed to **Mt Baker** on the 11th of February to replace a broken precipitation gage and apply some offset fixes to the total and 24-hour snowdepth sensors. This also gave them an opportunity to observe the very weak snow pack structure first hand, and they did several snowpits with the patrol to document the weak and weakening snow structure that existed near the surface at the time.

Although the **Chinook Pass** weather station experienced significant problems in early-mid February, considerable tweaking of the station parameters both at the office and by Crystal Mountain ski area electricians produced a miraculous fix in late February. Unfortunately, the problems quickly returned and both radio and modem were sent in to Campbell Scientific for repair after a lengthy repair trip and phone consult with CSI radio engineers failed to produce a fix for the continuing "no carrier" response from the RF modem after the station ID was transmitted. The repaired units were Fed-Exed back to the NWAC and will hopefully be successfully reinstalled by mid-March. Although the reinstallation was successful and contact was re-established with the remote stations, data access once again became problematic, periodic and then intermittent in late March and mostly out for all of April and May. With NWAC planning to cooperate with the NPS on several new stations on or near Mt Rainer over the summer, plans call for either installation of a new RF base station site at Sunrise (co-located with the NPS station) or conversion of this site to cell-phone at the Knob. Since the WSDOT has a vested interest in Chinook Pass data and their RF frequency would probably be the one utilized for any RF link, data from the resultant system would hopefully help all three agencies (NPS, WSDOT and the USFS).

Also a phone line problem—probably associated with corrosion or shorting of an exposed phone jack, became a problem with the **Paradise** remote station in early April. This was resolved by a quick trip to the site and replacement of a section of corroded cabling.

Anticipated Data Network Changes

If sufficient funding is available for both equipment and staff during the early summer and early fall (the NWAC is normally not staffed from late June-August), several significant changes are anticipated and planned for at several data sites. These changes have been alluded to or mentioned above and include substantial system modifications at Mt Baker, Washington Pass, Chinook Pass, Mt Rainier, Crystal Mt, Hurricane Ridge and near or just east of the Stevens Pass Berne Snow Camp at Nason Creek. These are further outlined below.

Mt Baker—
Replace NRCS meteor-burst telemetry system with phone line access. This should be accomplished with ski area support of installing a new buried phone line between the administration/maintenance building and the USFS A-frame, reprogramming the data logger, and replacement of the meteor-burst radio communication system with a phone modem. While in most instances the NRCS meteor burst communication preformed relatively reliably, this transition should allow for two-way communication and troubleshooting of the instrumentation from the Avalanche Center office.

Washington Pass—
Access to quality, real-time hourly information from this station has long been a problem for all of the parties involved (WSDOT, USFS and North Cascades Heli-Ski) due to intermittent satellite based transmissions and the reliance on an antiquated satellite based micrologger. To address this long-term problem, it is anticipated that WSDOT in cooperation with the NWAC will be able to design, have approved and install two new weather stations (one sheltered and one wind exposed) near Washington Pass that are linked by RF to a repeater near Mazama, and then connected to phone-RF base station in Mazama. Such a transition from satellite to RF link should allow changes to new precipitation and snow depth sensors and a much better and more exposed location for winds in the north Cascades. Also if the new system is completed, much more reliable two-way communication between office and the remote station(s) should allow for better programming and troubleshooting of problems with the weather data, as well as more timely data display. However, at this point funding problems may limit how much can be accomplished in a timely fashion during the summer and fall of 2003.

Chinook Pass, Mt Rainier, and Crystal Mt—
Inconsistent and unreliable RF communication with the Chinook Pass remote stations from the base station link at the top of Crystal Mountain are probably largely due to a

combination of one or more of the following:

- Long and deteriorating coax cable run from the base station to the antenna at the top of the Crystal Mt mountaintop restaurant building
- Bounce type/reflected RF transmission necessitated by the existence of a large topographic barrier (the King) between the base station and the remotes
- Problems with remote coax cables??
- Problems with remote radios, and/or power at the remotes??

Owing to these problems and the intermittent connections and sporadic receipt of data from the Chinook Pass remotes (not only for this past but for several past years), plans call for installation and use of a new base station in cooperation with the NPS and WSDOT (at Sunrise in Mt Rainier National Park) will allow for direct line-of-sight RF transmission to the higher elevation Knob 1 site. However, phone line availability at Sunrise may be a problem and this is being worked on.

All of this potential for a new RF link to the Chinook Pass station is possible as a result of an effort toward enhance weather instrumentation within the National Parks both region wide and nationwide. Within Mt Rainier, it is hoped that funding will be available for expanded instrumentation near Sunrise (two sites—an exposed site for winds and temperature, and a sheltered location for temperature, relative humidity, precipitation and snow depth), Ohanapecosh, Longmire, Camp Muir, and perhaps the summit of Rainier (for climber information and safety). With this expanded funding within the Park Service, other future instrumentation sites may be installed within Olympics and North Cascades National Park through cooperation of a variety of agencies—like that discussed in the spring NPS sponsored workshop—*North Coast and Cascades Monitoring Network Climate and Weather Workshop* (held April 28 and 29, 2003 at the NWS in Seattle).

Hurricane Ridge—
As mentioned above the current snow depth and precipitation sensors are often buffeted by strong winds or cross-winds that both limit the amount of precipitation measures and cause significant inaccuracies in snow depth due to the intermittent presence of large snow drifts that shift under the depth sensor. To eliminate or minimize such wind related problems, NWAC is proposing a installation of a new Rohn 45G tower about 50 yards to the west of the current station, near the manual observation site. If approved and funding allow, it is hoped that necessary tower, power and telemetry cables will be installed over the summer, with the site ready to go in the winter of 2004 (2005 or ??? if funding is not available).

Berne Snow Camp—
WSDOT Intelligent Transportation System (ITS) dollars may be combined with the NWAC need for more representative Cascade east slope stations to fund and install a new east side station(s) either at or just east of Berne Snow Camp near the Nason Creek rest area. Information from this site would be made available both locally (at a visitor kiosk) and on the Internet to enhance local weather information—both for the public and for forecasters.

OFFICE OPERATIONS

During the early fall, a new Windows based station data retrieval and formatting program was implemented to replace an outdated DOS-based basic program. After Garth and Mark recompiled and rewrote all of the micrologger programs in the new program format, Garth's long labors in the scheduling set up paid off in big dividends. The new system now stably collects the data, archives it, produces formatted output files and then automatically and efficiently transfers them to the National Weather Service computer network as well as our web site. Although the system is more understandable and more easily maintainable by all forecasters than the previous version, and in general it worked very well through the end of the year, it did experience a minor glitch at the year's changeover. The problem revolved around the program looking for a previous date (previous to J-date 1) and not finding one (since the previous J-date was listed as 365 for December 31st. Although the problem would have automatically corrected itself at midnight on the 2nd, we did not want the telemetry data to be out for 24 hours. Fortunately the problem was resolved by editing the raw dataset in the short term and substituting 0 for the 365.

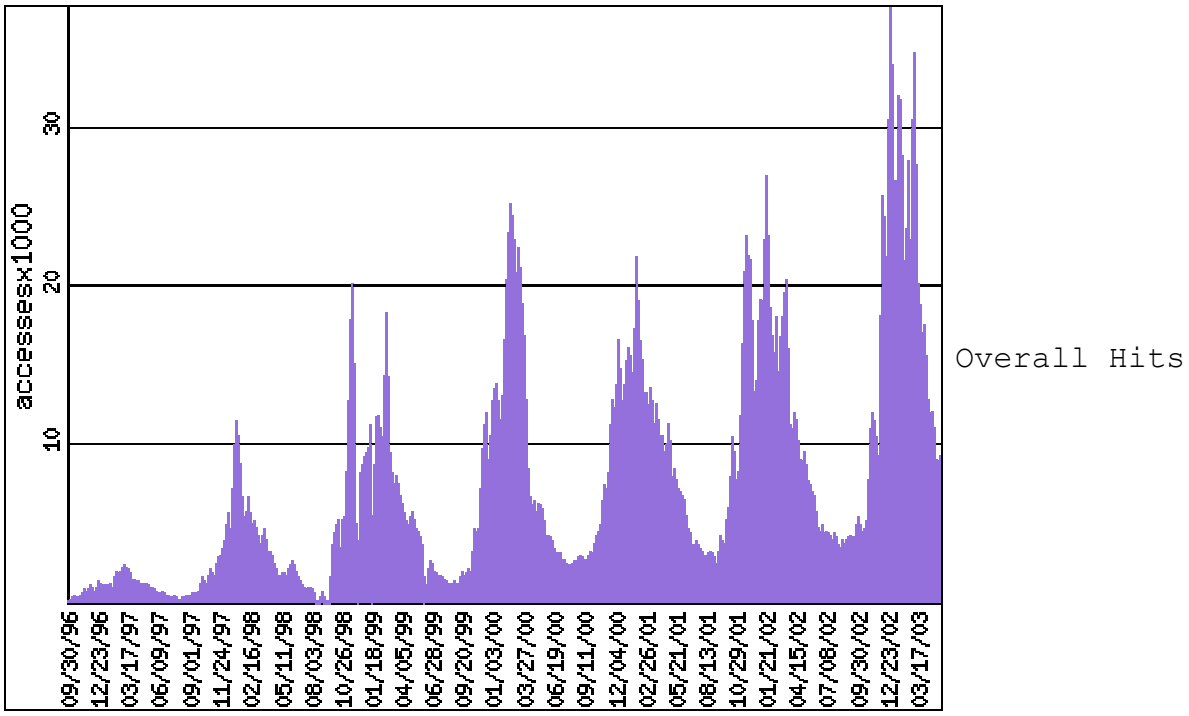
In other weather related developments, the Unix based graphics work station that the Friends organization contributed to the Avalanche Center mid-late last year came into its own in late November and December. While it lay unused for almost 6 months while the National Weather Service determined the best way to integrate it into the operational forecast system LAN and have it quickly access all of the various map and data products, an emphasis to have it and other similar workstations become operational came to fruition in the late fall. As a result, NWAC forecasters now have a reliable graphical

display of all forecast models and satellite imagery immediately adjacent to the forecasting composition and dissemination computer—an arrangement that has provided and should provide for easier model and data access, as well as better and more reliable forecast updates when forecasters are consulted during composition times. Despite the availability of the new graphical workstation within their office cubicle, forecast staff still are trying to do at least some of the early morning and afternoon update forecast research/briefings out on the main map floor in order to maintain continuity and a good working relationship with normal NWS duty forecasters.

NWAC Product Dissemination and Web Site

Although the winter of 2002/03 was slowly developing and many mid-late season rain events further dampened enthusiasm of winter travelers and recreationists, winter access of NWAC forecast and data products continued to expand dramatically over the previous season, especially on the web site (www.nwac.noaa.gov and www.nwac.us). By late May, Internet accesses of data and forecast products alone registered over a 20% increase above the previous record setting years of 2000/01 and 2001/02 (about 1.1 million hits were recorded in 2000/01, 1.6 million hits in 2001/02, and over 1.88 million in 2002/03). The NWAC web site also a recorded record setting number of visits and accesses. Historical weekly web site visits of the NWAC web site since its inception in 1996 are shown below. This figure shows that access is not only greatly increased during the winter months, but the web site also is showing a less dramatic but sustained growth during the summer time—probably from recreationists using links to a variety of educational materials as well as other sites and snow/weather related information. Note that the web site visits shown here do **not** include the direct file accesses (hits) shown in the forecast and data hit charts below.

Figure 17. NWAC Web Site history from 9/30/96 to 5/17/2003—Weekly site accesses (x1000)



However, as has been mentioned in earlier reports, many users of NWAC products bypass the NWAC web site and go directly to the files that are stored on the NOAA-NWS server. Also, a variety of other web sites download the products and then store them for display and dissemination locally. Since NWAC has no way of knowing dissemination totals through these and other means, the contact figures below represent the lower end of user accesses of data and forecast products. In any case, as of May 18th, **total direct data and forecast accesses for the past season (September 28-May 18, 2002 or ~8 months) reached almost 1.9 million hits (1.88 million), with about 2 million annual hits projected for the year**. This is in addition to over 540,000 accesses of NWAC web site pages. Access data for both seasonal forecast hits and combined data and forecast hits are shown in Figures 18-21 below. As signs of rapidly changing times, it is interesting to note that while the avalanche forecast hotline phone numbers (503-303-2448 in Portland and 206-526-6677 in Seattle) are still active, usage continues to slowly decline (Figure 18 below). However, accesses of these same forecasts via the Internet (Figure 21) have increased dramatically and now average **over 25,000 hits per week** (during the core of the season). See also the overall forecast and data access comparison between the 2001/02 winter and the 2002/03 winter below. It is believed that the this greatly increased forecast dissemination—as well as of the hourly mountain weather data—are all helping users to make wiser and safer decisions about trip planning and general travel in the back country.

Figure 18. Annual Phone Calls to Avalanche and Weather Hot-line Recorders (1991-2003)

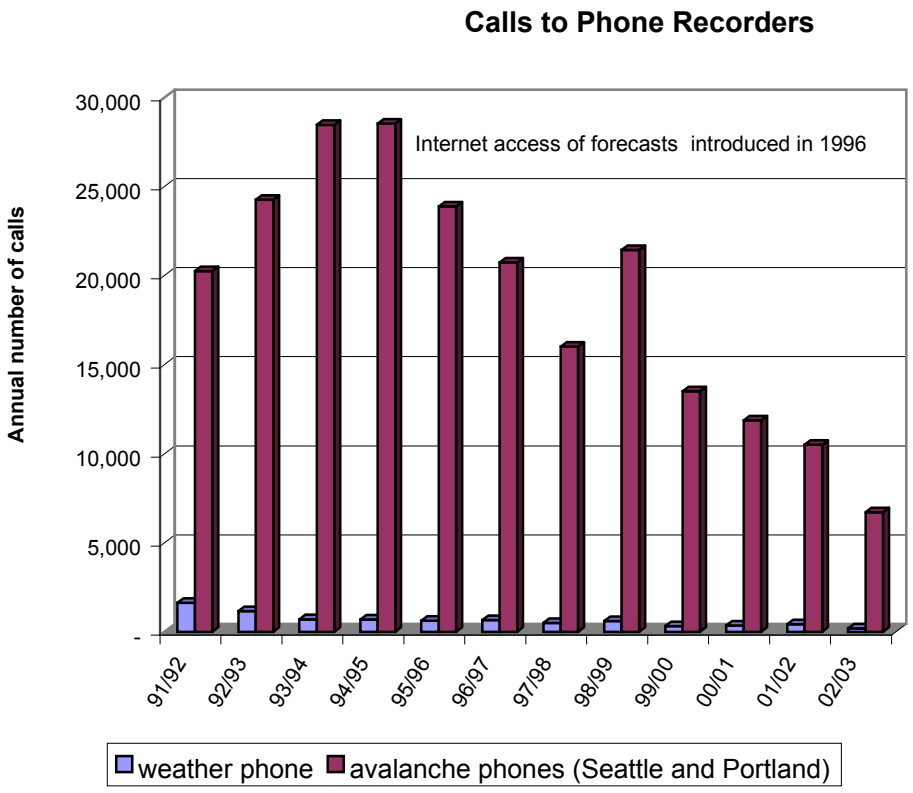


Figure 19. 2001/02 NWAC **forecast and data** accesses (hits) via the web

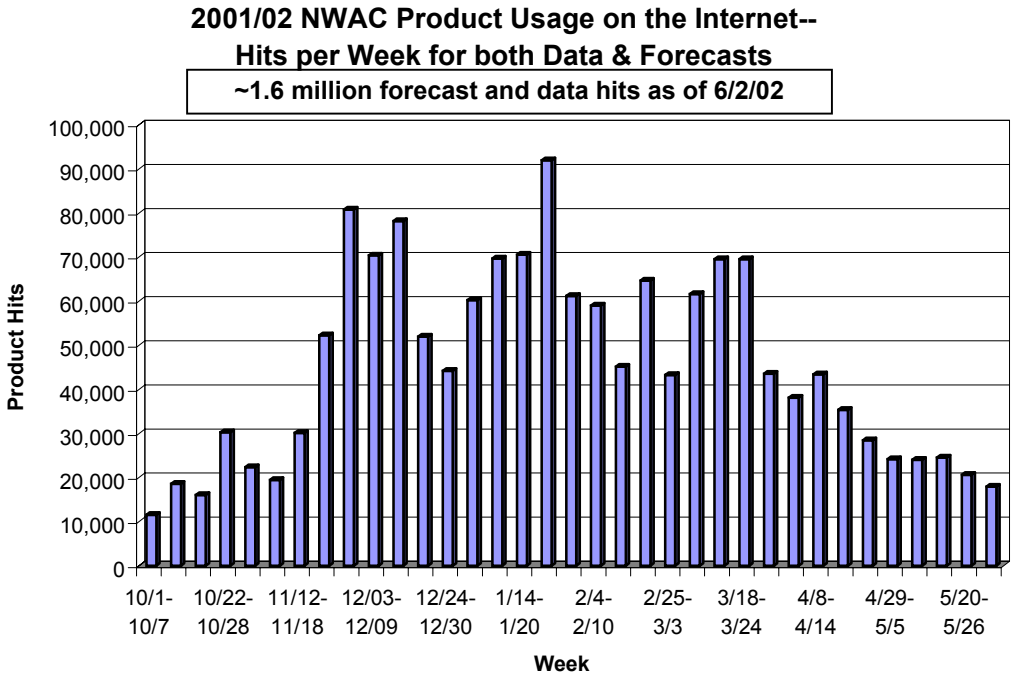


Figure 20. 2002/03 NWAC **forecast and data** accesses (hits) via the web

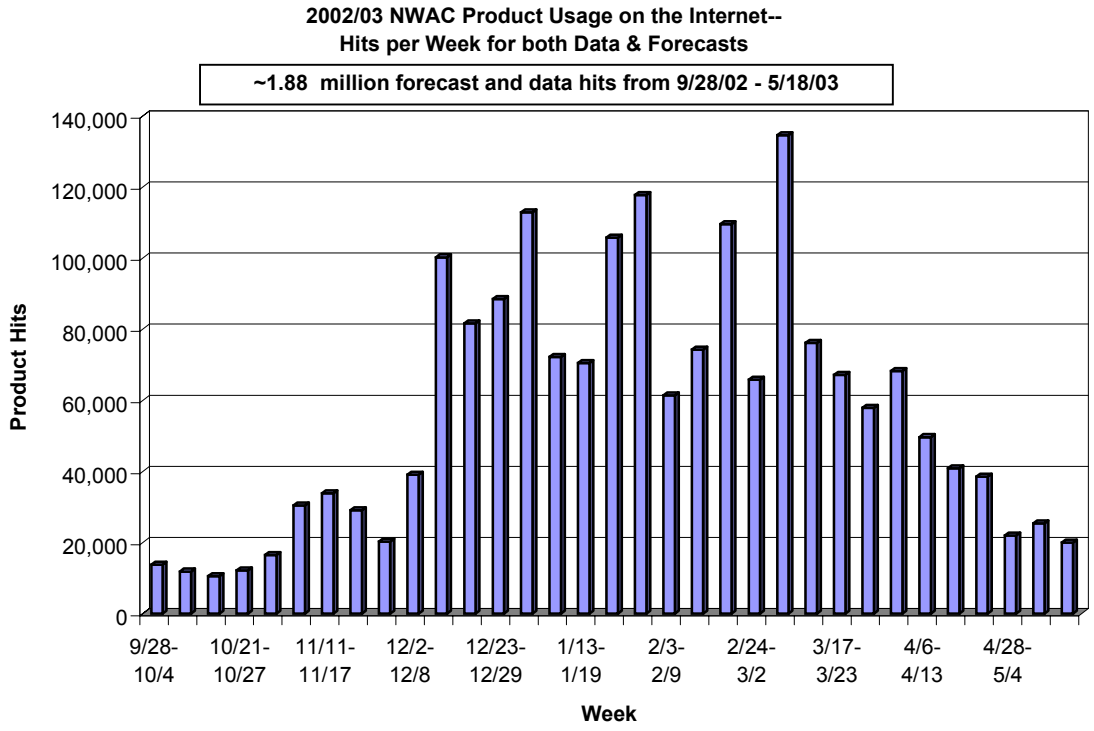
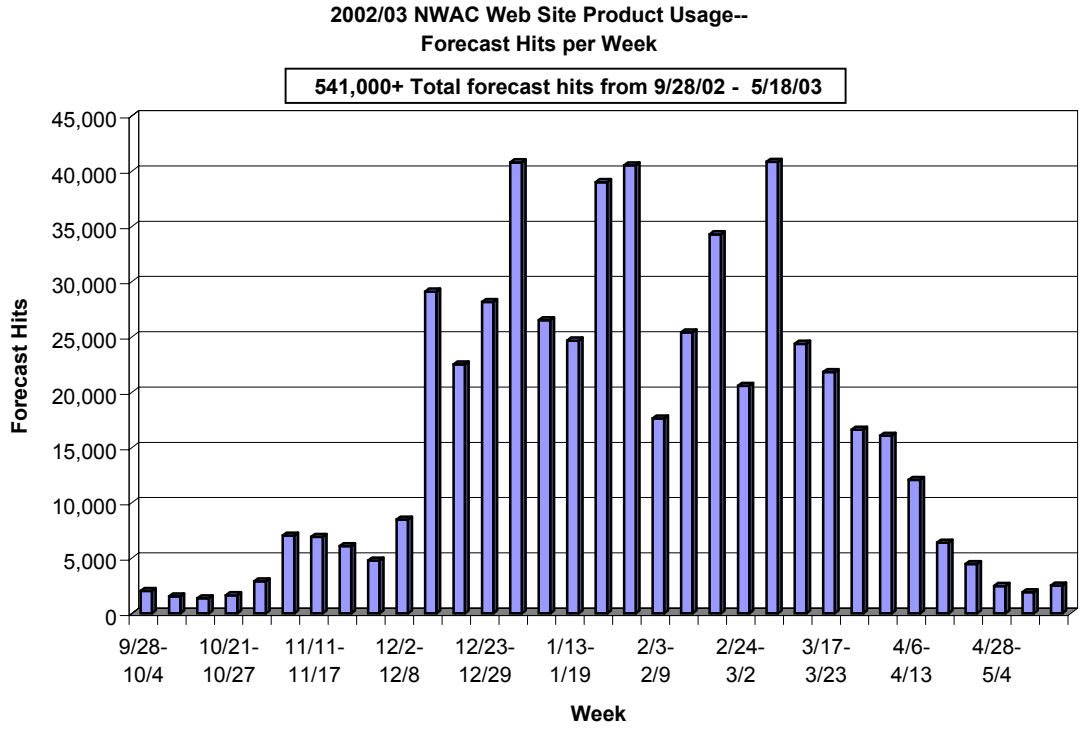


Figure 21. 2002/03 NWAC **forecast** accesses (hits) via the web



NWAC TRAINING

With the help of the Mt Baker Snoqualmie Personnel and Purchasing office, the NWAC instituted a meteorologist intern program this season. As a result two qualified individuals were hired on a personal services contract to begin training as future avalanche forecasters—possibly to fill in during future absences or sickness of regular forecasters. Both individuals—Ms. Amy Haase and Mr. Dave Erickson—had prior snow, avalanche and weather experience, and it is hoped that such training efforts will help provide for a pool of enhanced expertise for both local and other avalanche forecasting efforts in the future.

In late January, Kenny Kramer attended a workshop presented by Eric Grimit from UW/NWS on the MM5 meso-scale forecast products available on AWIPS workstations at the Weather Service. Eric is involved with the assimilation of the various MM5 model configurations onto the NWS AWIPS workstations. These short-range ensemble forecasts are used to help with detailed forecasting through 48 to 72 hours. The MM5 is run using a "core" of eight different models. From the output of these eight separate model runs, a "centroid" model output is produced as another individual member. The "centroid" output is made up of the differences between the "core" model runs and has been shown to often outperform any of the individual "core" members. With the increased wealth of model data available to forecasters, knowledge of these various products and how they are produced helps to assure that the NWAC issues the highest quality forecasts.

As time and funding allow, forecasters are also planning to develop experience with the new graphical forecast gridded data displays currently being utilized and enhanced by the National Weather Service throughout the country. It is hoped that through adjustment or editing of some of the graphical displays that more visual avalanche forecast products will ultimately result, and forecast staff hope to be able to make strides on this "front" by next fall.

PUBLIC RELATIONS / EDUCATION

All NWAC forecasters attended the International Snow Science Workshop held in Penticton, British Columbia from September 29th through October 4th, garnering a lot of early season knowledge and wisdom and getting into the proper framework for the subsequent winter. Just prior to the ISSW02 opening, Mark gave a short talk about forecasting operations at an ancillary meeting at the same location—the International Avalanche Bulletin Writer's Workshop.

The NWAC expanded its educational reach toward snowmobilers at the Washington Snowmobile Expo on October 19-20, with several other educational efforts targeted primarily toward snowmobilers throughout the year. Mark had adapted a PowerPoint presentation developed by the Gallatin National Forest Forecast Center (Southwest Montana Avalanche Center) for the Northwest, and both Kenny and Garth used it as the basis for snowmobile avalanche awareness presentations at the expo, reaching a combined audience of 80-100 sledders.

During December into early January Mark also revised and rewrote much of the old Pacific Northwest *Snow Avalanche Brochure (Basic Principles for Avoiding and Surviving Snow Avalanches)*, including suggestions and feedback from a variety of user groups, Mt Baker Snoqualmie National Forest personnel, and the *Friends of the Avalanche Center* board members in the rewrite. With the support of the FOAC, the Avalanche Center plans to republish the revised and updated brochure over the summer to help enhance avalanche awareness efforts in the Northwest. The brochure will also be slightly reformatted for inclusion as a primer source of on-line avalanche education on the web site—after the final draft is approved and headed for the presses. Mark also commented on an *Avalanche Safety* primer for the Children's Hospital in Seattle, with the primer to be distributed at the Children's resource center. He also revised and updated an *Avalanche Hazard* section in the Federal Emergency Management Agency-FEMA handbook for FEMA managers, among others.

Despite the late start to the winter season, back country users and program cooperators jumped into increased data and forecast access on the web site as early as October. 10-15,000 hits per week on avalanche and weather products (forecasts and data) in October quickly increased to 80-100,000 hits/week by the time forecasting operation got underway in mid-December.

The NWAC's Internet address — http://www.nwac.noaa.gov has become widely distributed during recent years and it is a well-known destination for information about mountain weather, snow and avalanche information. Unfortunately there is a possibility that the NOAA server that has hosted the NWAC web site for its entire history may lose funding

for maintenance of the server. If this occurs, NWAC may need to seek a new server and/or URL address. In order to make this an orderly a transfer as possible, and to provide for an unchanging web address overall, NWAC has reserved the web address **nwac.us** to act as both a current and future pointer to whatever server location and address may become necessary. The Friends group is helping with the funding process for this new name and the current web site info can be accessed by entering one of the following:

- nwac.us —points to the home page for www.nwac.noaa.gov
- www.nwac.us —points to the home page for www.nwac.noaa.gov
- data.nwac.us -points to the data page on nwac.noaa.gov
- forecasts.nwac.us -points to the forecast page on nwac.noaa.gov
- accidents.nwac.us -points to the accidents page on nwac.noaa.gov
- education.nwac.us -points to the education page on nwac.noaa.gov
- friends.nwac.us -points to the *Friends of the Avalanche Center* web site

On the 6th of February, several representatives of the Chinese Central Television Service (a producer/cameraman and reporter/program manager) visited the Avalanche Center and the National Weather Service Forecast Office, spending 3-4 hours interviewing forecasters and staff with both offices. These interviews are being combined with other field and avalanche office opportunities in other areas over the next few weeks to create a Chinese news documentary on avalanche forecasting efforts in the United States. It is hoped that NWAC can get copies of such a video, but translation might prove to be difficult.
With the great public furor over the two large Canadian avalanche accidents in late January, NWAC forecasters received considerable newsmedia interest about avalanches. As a result the staff participated in extensive interviews with reporters from print, radio and television. Television interviews included CBS News and KIRO-TV, while newspaper interviews included the LA Times and New York Times with several front page articles resulting in the Seattle Times, Seattle PI, and the New York Times.

Mark taught several beginning and advanced level avalanche awareness classes at Crystal Mountain in late January and early February, and again in Montana in late February and early March. It is hoped that this training as well as other training throughout the year by members of the forecast staff will have a positive effect on reducing avalanche accidents. The training continued in early March when Mark and previous Forest Service liaison and acknowledged forefather(along with Dr. Ed LaChapelle) of the Avalanche Center Roland Emetaz presented a 2+ hour presentation on avalanche awareness to a some 70 excited students in a beginning climbing class with the Tacoma Mountaineers. Mark also gave a short but relatively well-received presentation on the history and evolution of the Avalanche Center at the all-recreation meeting of the Mt Baker Snoqualmie National Forest. This was quickly followed by several presentations during the week of the second Washington State Avalanche Awareness Week from the 16th-22nd of March, so proclaimed by Governor Gary Locke. During this Awareness Week, Mark gave talks at both REI in Seattle and at the Mt Baker Ski Area—who co-hosted the Awareness Week's Education Effort with the Avalanche Safety Awareness Program (ASAP) in Bellingham. A chart of NWAC and FOAC educational presentations and the approximate number of participants is shown in the Table below. In general, such educational presentations have been averaging around 1500-2000/year.

In the weeks ahead from the time of this annual report publication through the close of the season, forecasters will continue to develop and enhance the educational efforts of the Center. These efforts will include finishing and printing of the new Northwest Avalanche Brochure (mentioned above), as well as continuing work on adding more educational content to the NWAC web site, including a guide to field forecasting and an on-line avalanche and mountain weather glossary. Plans also call for adding most of the content of the new brochure to the web site if time, staffing and funding permit over the summer.

It is also hoped that the training and application of the data-formatting program *Strov* will allow graphical data displays to be automatically added to the web site over the 2004 season. Mark plans to meet with the program developer(s) in June to learn and enable such possibilities—not only to help forecasters analyze the data, but also to help all the users who sometimes balk at digesting and effectively utilizing lines and lines of weather related numbers.

Table 1. Summary of NWAC (& FOAC) Educational Presentations

Date	Organization	#	Location	Speaker
19 October	WA State Snowmobile Exposition	20	WA State Fairgrounds, Puyallup	Kramer
20 October	WA State Snowmobile Exposition	20	WA State Fairgrounds, Puyallup	Ferber
23 October	Mountaineers	30	Everett	White
7 November	Puget Sound AMS	40	NOAA Seattle	Ferber
12 November	Olympic Mountain Rescue	25	Bremerton	White
14 November	FOAC Fundraiser	150	REI Seattle	Moore
15 November	FOAC Fundraiser	200	REI Seattle	Ferber
18 November	AIARE Instructors	20	Everett	Moore
2 December	Sno Joke Ski Club	26	?	White
3 December	Mountaineers	30	Everett	White
9 December	Mountaineers Winter Travel Class	65	Tacoma	Emetaz
11 December	Mountaineers	50	Seattle	White
30 December	KIRO TV		Seattle	Ferber
30 December	KXL Radio		Portland	Ferber
30 December	NW Cable TV News		Seattle	Ferber
31 December	KIRO TV		Seattle	Ferber
2 January	KEZX Radio		Portland	Moore
9 January	Mountaineers Ski-Snowshoe Class	40	Olympia	Emetaz
18 January	NAI Level 1 Class	45	Crystal Mountain	Moore
19 January	NAI Level 1 Class	45	Crystal Mountain	Moore
21 January	CBS TV		Seattle	Kramer
21 January	KIRO TV		Seattle	Kramer
23 January	Mountaineers	38	Everett	White
29 January	Boy Scouts	120	Everett	White
1 February	Trout Lake XC Skiers	35	Trout Lake	Emetaz
1 February	NAI Level 2 Class	46	Crystal Mountain	Moore
1 February	NAI Level 2 Class	46	Crystal Mountain	Moore
6 February	CCTV China		Beijing, China	Moore
19 February	KEX Radio		Portland	
22 February	Mountain Rescue Field Session	15	Olympics	White
1 March	NAI Level 2 Class	24	Big Mountain, MT	Moore
2 March	NAI Level 2 Class	24	Big Mountain, MT	Moore
5 March	USFS/MBS Recreation Meeting	45	Blaine	Moore
6 March	WA Ski Touring Club	50	REI Seattle	Ferber
8 March	Q-13 TV News		Seattle	Haase
8 March	NW Cable TV News		Seattle	Kramer
12 March	Mountaineers Basic Climbing Class	75	Tacoma	Emetaz, Moore
17 March	REI	15	Seattle	White
26 March	Mountaineers Scramble Class	55	Tacoma	Emetaz
7 April	Wilderness Experience Store	40	Olympia	Emetaz
25 April	CWU Class	12	Snoqualmie Pass	Moore
29 April	NPS Climate Workshop	40	NOAA	Moore
	Total	**1486**		

APPENDIX

NWAC and Avalanche Related Articles

The New York Times ON THE WEB

February 14, 2003

By TIMOTHY EGAN

Courting Disaster, in Search of Snowy Thrills

GLACIER, Wash., Feb. 9 – One after the other, 42 snowboarders launched themselves off the shoulder of Mount Shuksan in a silent salute to a fallen pioneer of their sport, Craig Kelly, 36, who was killed in an avalanche last month.

But high above them, in the untracked snow of the North Cascades, other snowboarders were perched at the intersection of risk and stupidity, preparing stunts that even Mr. Kelly might not have tried.

The snowboarders had been warned of death by avalanche, and beyond — "you or your heirs will be charged for rescue," the Forest Service signs said. Still, they dropped into the snow chutes, setting off small slides, yells of thrill echoing in the canyons.

"Craig Kelly was a hero to all of us, but his death seems to be just part of the game," said Shane Drexler, 26, a snowboarder who once nearly died in an avalanche but is still drawn to deep, unstable snow.

The game — courting avalanches, pushing into the highest, untracked reaches of snowbound mountains — has of late turned particularly deadly. Last winter, 35 Americans died in back-country avalanches, the most ever. The previous high was 33 in the winter before.

Over the past decade, avalanche deaths have risen, mostly among snowmobile riders, but more and more snowboarders and back-country downhill skiers have also died.

The numbers this season are slightly below record level. But in the past month, two avalanches have killed a total of 14 people in British Columbia, including one that claimed Mr. Kelly, who did things on a snowboard that once were unimaginable. Three other Americans died in the avalanche that buried Mr. Kelly. So far this winter, 15 Americans and 16 Canadians have died.

Despite a weather pattern from El Niño that has delivered snow than usual to the West, most experts do not blame the elements. An avalanche, they say, is the only natural disaster that is usually set off by victims. What has changed is human behavior in the mountains.

"When I started looking at avalanches 25 years ago, the only people you'd see in the back country were the rare telemark skiers, and those people were thought to be real weirdos," said Bruce Tremper, director of the United States Forest Service's Utah Avalanche Center. "The conventional wisdom was you don't go into the back country in winter."

But just this weekend, Mr. Tremper estimated, more than 2,000 people in the Salt Lake City area alone ventured into the wilderness by snowmobile, skis or snowboard. They were all seeking the same thing: a slope with untouched snow.

In the 1970's, Colorado had "ski to die" clubs, skiers who tried to make tracks in places that made most people's hearts stop on sight. Since then, the toys and the challenges have changed considerably, inspired in part by a subculture that celebrates extreme sport and gravity defiance in all its contortions.

"Now we've got some people actually trying to cause avalanches," said Mr. Tremper, who spends his mornings examining snow stability to put into a daily avalanche report. "It's a sport."

Mr. Tremper recently spotted a bumper sticker on a truck bound for Utah's back country. "On the edge for you is the middle of the road for me," it read.

For snowmobilers, the sport is called high-marking. The object is to ride as high as possible on a steep, typically untouched flank of snow.

"It's a lot of fun," said Darin Bryant, a Seattle snowboarder and snowmobiler. "But stuff happens."

The records of avalanche deaths this year complied by the Colorado Avalanche Information Center, which tracks

North American avalanches, show the kind of accidents that follow people who hunt for unsteady snow.

The center's listings from this month include the death of a snowmobiler in the Crazy Mountains near Livingston, Mont. It is just one of many: "One snowmobiler caught, buried, killed. Two snowboarders caught and buried, one rescued, one killed. One solo snowboarder caught, buried, and killed."

Here in Washington, more people die in avalanches — 15 since 1996 — than in any other natural disaster, according to the federal Northwest Weather and Avalanche Center in Seattle.

"We're killing more people in avalanches every year than die in wildfires or floods," said Mark Moore, director of the avalanche center. "And a lot of those people, they're out there looking for the very slope that's mostly likely to come down in an avalanche."

Just above this village near the Canadian border, weekend snow warriors carry battery-powered beacons that send out a locating signal, snow shovels and even balloons that inflate to take a victim above the snow. But the tools can provide a false sense of security.

"It's not a talisman to have all these tools," Mr. Moore said.

The flip side of caution is the joy that comes from leaving the bonds of earth, even for a few seconds. All over Mount Baker last weekend, snowboarders wore T-shirts reading, "Craig Kelly is my co-pilot."

Mr. Kelly, known as a "snow rat" from his early days on the slopes of Mount Baker, dominated the world circuit of snowboarding in the late 1980's and early 1990's, while pioneering numerous airborne stunts.

Mr. Drexler, as did many other snowboarders, worshiped Mr. Kelly. But he has learned the hard way that untracked snow can be deadly. Two years ago he and a friend tried to snowboard down an out-of-bounds ski area near Alpental, a resort in the central Cascades, when he was caught in a fast-moving slide.

"I held onto this tree, but the avalanche pulled me away," Mr. Drexler said. "All of sudden, I'm like, whoa, I'm coughing, my goggles are clogged, this cloud of snow is carrying me down. I did everything I could to stay on top of it, and I lucked out."

Now Mr. Drexler is a changed man — to a degree. He carries a beacon that transmits a signal allowing people to find him if he is buried. But he has not followed through on plans to take a class on avalanche safety.

"Yeah, I should be taking the class," said Mr. Drexler, as he prepared for a snowboard run at the Mount Baker Ski Area near Glacier, about three hours north of Seattle.

When snowboarders and skiers arrive at Mount Baker, the first thing they see is a sign boasting that the resort owns the United States record for most snowfall in a single season — 1,140 inches, in the winter of 1998-99. That kind of snow draws risk-takers, but it also takes its toll. During that record winter, three people died in avalanches near here.

"We have a strict policy on out-of-bounds skiing and boarding, but people see these videos, these magazines, these stunts, and it just draws them in," said Duncan Howat, general manager of the Mount Baker Ski Area.

"People wonder what Craig Kelly must have felt during his last minutes alive — I know, because I was buried once," Mr. Howat said. "All I could think was how stupid this was. How I was never going to see my wife and two daughters again, and it was all because of this stupid act."

Classes in avalanche safety are packed, ski operators say. Yet even with the high death toll in recent winters, there are few calls for restrictions.

"I don't think it's appropriate to restrict access to public land," said Mr. Tremper of the Utah Avalanche Center. "We all own it. It's our greatest heritage. And instead of being locked up, as some anti-environmentalists say, it's the opposite — it's total freedom."

Most avalanche deaths occur on public land outside designated skiing and snowboarding areas.

"Snowboarders are an independent group," Mr. Moore said. "They don't want to be told where to go or what to do. They want to go places where the avalanche lives."